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TRANSLATION

CONSTRUCTION OF AIRPORTS

By

A. A. Gerberg and A. S. Osipov

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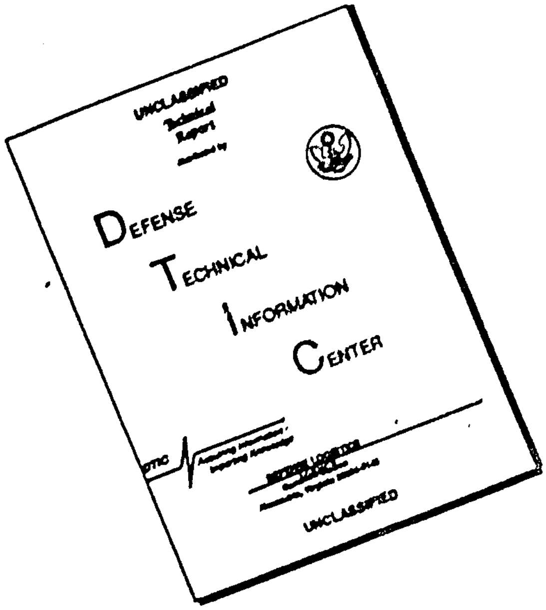

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UNEDITED ROUGH DRAFT TRANSLATION

CONSTRUCTION OF AIRPORTS

BY: A. A. Gerberg and A. S. Osipov

English Pages: 405

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A. A. Gerberg and A. S. Osipov

STROITEL'STVO AERODROMOV

Nauchno-Tekhnicheskoye Izdatel'stvo
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Moskva 1962

331 pages

This translation was made to provide the users with the basic essentials of the original document in the shortest possible time. It has not been edited to refine or improve the grammatical accuracy, syntax or technical terminology.

TABLE OF CONTENTS

This book presents the principles of organizing airport construction. It describes preparatory, earth-moving and agricultural operations and shows the construction of the water drainage network.

An extensive description is given of the types of airport pavements and of the methods of constructing them.

Recommendations, based on study of advanced experience of airfield construction organizations, are given about adapting the most effective methods for executing the work with maximum utilization of mechanization facilities.

This book was written for use by engineers and technicians.

FOREWORD

In connection with the continuous development of air transportation in the USSR, the volume of airport construction increases with each year.

Air transportation of passengers, due to the adaption of high speed, large seating capacity jet and turboprop aircraft will increase by a factor of more than 6 in the [next] seven years.

The construction workers successfully fulfill the plan for rebuilding and building airfields, equipped with modern aircraft handling facilities and for extending the network of airports of local air routes, laid out by the CPSU.

On the basis of domestic and foreign experience, the Soviet airport builders, equipped with high-productivity equipment, increase with every year the rates of airport construction, constantly improving the quality of work and decreasing its cost.

This book has made an attempt to correlate the leading experience of airport building organizations and innovators in adapting effective methods for performing individual kinds of operations, advanced working procedures with maximal utilization of mechanization facilities and progressive implements and tools.

The authors, in presenting methods and procedures for performing individual types of airfield construction operations which have been proved in actual practice have, also, tried to illuminate procedures for working with machines and equipment which are assimilated by our industry and are beginning to be adapted to the practice of work of air-

field construction organizations.

The book gives the procedures for building take-off and landing strips (VPP) [runways], taxiways (RD), single aircraft (MS) and terminal site aprons, ground strips, water regulating and drain installations. The construction of simplified, refined and asphaltic concrete pavements is presented in a very compact form, since these types of operations are sufficiently illuminated in technical literature devoted to the construction of automobile roads.

The foreword, Chapters 1, 2, 9, 10 and 11 were written by engineer A.A. Gerberg and Chapters 3-8 are due to engineer A.S. Osipov.

The authors consider it their obligation to express their deep appreciation to engineer M.S. Gurarye for useful advice and remarks in preparing the work for publication.

We ask that remarks and requests should be sent to: Moscow, I-92, Sretenka, 27/29, Avtotransizdat [Publishing House for Automobile Transportation Literature].

Chapter 1

PREPARATORY WORK

1. PURPOSE AND COMPOSITION OF PREPARATORY OPERATIONS

Operations which are performed in order to assimilate and prepare the construction site proper, ase classified as preparatory. They should be executed strictly on schedule, thus ensuring normal development of performance of basic airfield construction operations, i.e. earthmoving, for constructing the water draining network and pavements, etc.

Preparatory operations include: stacking out the layout on location; pulling of stumps, felling trees and hauling out the timber; removal of stones, clearing the site of brushwood and small trees; removal of peat and moss, cutting off of hillocks; breaking up and removal of old pavements; removal of existing structures and utility networks; preliminary dewatering the construction site.

A modern airport occupies a large area, as large as 500 hectares and more. It is completely obvious that it is practically impossible to find a land mass of the necessary size which would not require preparation. As a rule, in preparing the construction site, one encounters different kinds of land clearing work, the volume and character of which depend on local conditions.

Construction of airports in the northern woodland regions, even on good sites, require a large volume of land clearing work of all kinds, while work in steppes region does not require felling of trees, pulling of stumps, dewatering, etc.

Sensibly performed land clearing work has a considerable influence

on decreasing the labor time required and the cost of construction work.

All land clearing work should be performed in accordance to specific engineering plans, providing for proper organization of work, most efficient placement of equipment and sequence of operations.

2. STAKING OUT THE SITE

Procedures for Staking Out the Site

Staking out the site, consists in marking off and staking out at the site, of axes and contours of runways, taxiways, terminal-site and individual aprons, the route of the water drainage network, airport structures and approach roads. The boundaries of land clearing, earth moving and other airfield construction operations sections are also marked on the site.

The airport plan can be staked out in parts, in accordance with the established construction sequence.

The starting materials for staking out the site are:

1. Schemes of planned grounding and position of surveying monuments.

2. Working drawings for staking out the site (marking drawings).

3. Documents giving the coordinates and elevations of corner points and land monuments.

The scheme of planned grounding and positioning of surveying monuments gives all geodetic symbols and their numbers, the length of the sides of the reference network, the values of [corner] angles and the elevations of land monuments.

The marking drawing is a scheme of individual subsections of the plan, for example, the layout for marking off of runways, taxiways, aprons, marking the boundaries of earth moving operations and of the drainage system.

The marking drawing presents all geodetic data about staking out

the site. The marking drawing for runways, taxiways and aprons is drawn to a 1:2000 scale.

After the plan is studied, the first stage of staking work consists in detailed checking and restoration of the existing geodetic reference network.

The checking is done by going past each control point of the reference network and comparing them with the plan. This inspection tour also includes conformance of the points on the drawing to the locality landmarks and marking off of control transit and level lines along the reference network which would provide positive checking of all elevations of all basic monuments, from which surveying work will be performed. All shortcomings of the reference network that are found, should be eliminated. The results of the inspection are recorded in the act of accepting the reference network.

After the reference network was checked and restored, the longitudinal axes of runways, taxiways and individual aprons are marked off and staked out. The precision with which the design values for airport structures are marked off, should conform to category IV leveling in case of elevations and to the precision of transit lines in the plane. The height deviation should not exceed $\pm 15\sqrt{L}$ mm, where L is the length of line, or the perimeter of the polygon in kilometers. The angular deviation in a closed polygon, or of an individual line, should not exceed $\pm 1.5\, \underline{t} \sqrt{\underline{n}}$, where $\underline{t}$ is the precision of the instrument and $\underline{n}$ is the number of angles in the polygon or in the line. The linear deviation of a line and also the difference in distances measured when proceedin in the forward and reverse direction, should not exceed 1/2000 of the length of the line. The lines are usually marked off by 20 or 24 meter steel ribbons, checked with a standard, in the forward and reverse directions.

Staking Out on the Site of Runway, Taxiway and Apron Center Lines

Center lines of installations are staked out on the site by types I, II and II land monuments (Fig. 1).

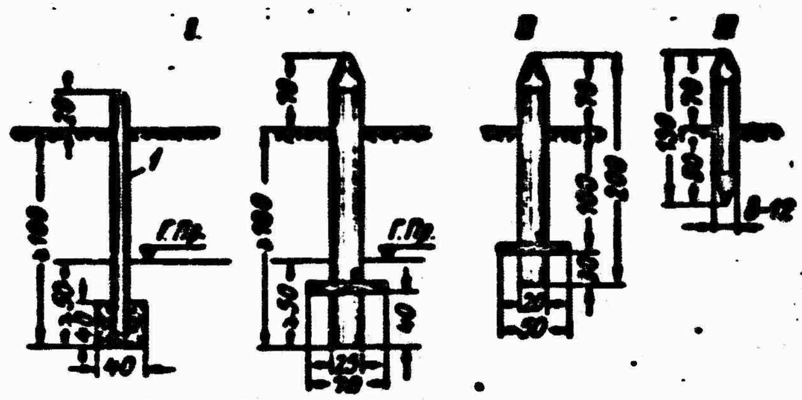


Fig. 1. Types of land monuments.
1) Pipe; G. Pr. the elevation of the depth to which the soil freezes.

When staking out the site for pavements, center lines are marked off first and then, all cross sections are taken and staked out. Subsequently, in the process of constructing the subfoundation channel, the foundation and pavements, the network of points is made denser as the necessity arises.

The runway center line is staked out by placing two type I markers on each side - a total of four markers (Fig. 2).

The distance between markers is determined depending on the local conditions as 100-150 and 250-350 meters.

In addition to the center line, the beginning and the end of the runway is also marked off by placing type III markers.

Staking out of the center line of group stand-by aprons and terminal-site aprons does not differ from the staking out of runways. The center lines of individual stand-by aprons are staked out by type II markers, which are placed to each side of the apron at a distance of 100-150 meters of their outside limits (Fig. 3).

Additionally, in case the main monuments are damaged and also for

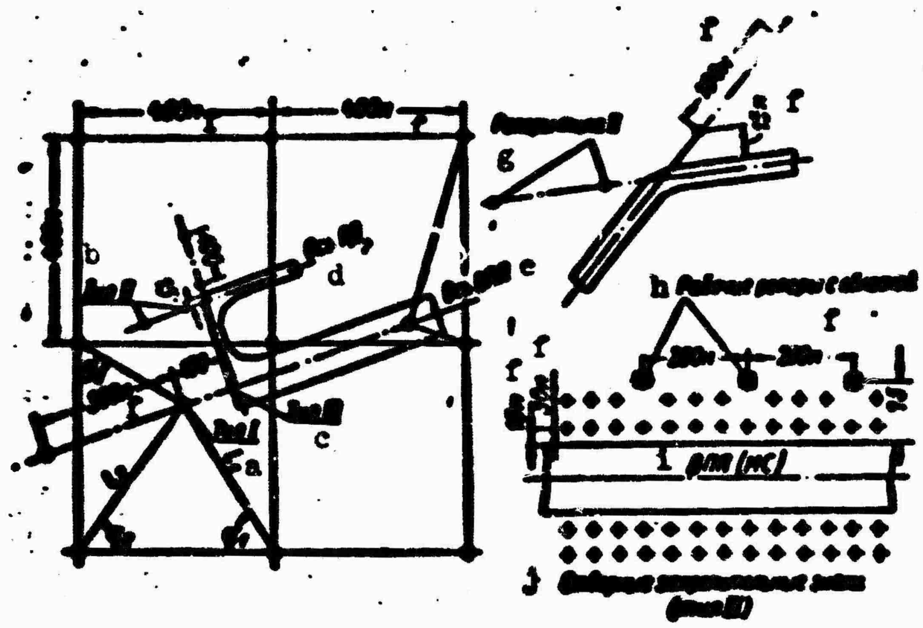


Fig. 2. Scheme for staking out the center lines of runways and taxiways. a) Type I; b) type II; c) type III; d) taxiway axis; e) runway axis; f) meters; g) type II monuments; h) working monuments with fencing; i) runway (apron); j) directional markers (type III).

checking in the process of work, type II markers are placed every 200 meters parallel to the runway center line (see Fig. 2).

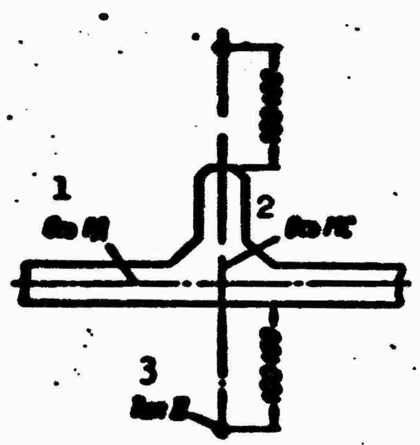


Fig. 3. Scheme for staking out individual aprons. 1) Taxiway center line; 2) apron center line; 3) type II.

Prior to commencement of airport construction, the land boundaries, which will serve as the airport boundaries, should be staked out.

The land boundaries are established by a commission with the participation of the authority taking possession and representatives of local land authorities. The commission compiles documents of gounds (grazing lands, gardens, forests), condemned for airport construction and also a document of installations being removed, attaching a plan and their detailed description. The airport boundary is marked off by landmarks which consist of small concrete piles, placed at the vertices of corner angles and on straight sections,

if the distance between angle vertices is greater than 300-400 meters.

In staking out the site (in placing stakes and control line), a field book is kept in which a record is made of all local conditions which were not reflected in the plan (local marshy patches, the ground water level, etc.) and also of changes which took place since the surveying till the beginning of work.

Staking out of the site is a critical stage of operations, for which reason its results are made formal by an act which is signed by the representatives of the construction organization and of the technical supervisor of the airport operating authority. The act should be supplemented by the execution scheme, showing the staking layout for center lines of runways, taxiways, aprons and other structures, giving the location of all installed monuments and actual data about their coordinate relationship to the reference surveying grid network. The act also gives the procedures according to which checks were made and the deviations thus found.

The staking out of the earth moving plan starts with checking and restoration of the leveling grid of squares 40 x 40 (20 x 20) meters. The square grid network usually must be staked out anew. This is done by using a transit and a 200 meter cable, starting from the vertices of the square grid network (400 x 400 meters). The square grid network (40 x 40 meters) is restored only at the earth-moving sections.

After the square grid network has been restored, the contours of cuts and fills are staked out by placing wooden pegs painted with brilliant colors along the perimeter.

The elevation of the design surface is staked out by stakes which are placed in the nodal points of the 40 x 40 meter grid network and also at characteristic intermediate points. Guarding pegs are placed alongside the stakes. The actual difference between the top of the stake

and the ground surface, will give the working elevation at the given point.

In fills, the stakes will rise above the ground level, while in cuts, conversely, they will be sunk below the level.

When the cut depth is considerable and a large amount of earth-moving work is performed by machines, it is recommended that first holes should be dug in the nodal points of the square grid network, approximately till the design elevation and then be filled with sand, lime or other materials, which contrasts sharply with the color of the soil being moved, rather than to place stakes. When about 20-25 cm remains to the design elevation, the stakes are placed and the surface of the airfield, till thedesign elevation is reached, is excavated according to them. Ranging rods are used for staking out the earth-moving operations in-between the grid nodal points.

3. REMOVING STUMPS

General Information and Composition of Operations

In a number of cases, clearing of land for an airfield requires mass removal of stumps. This work is very labor-consuming and should be entirely mechanized. The stumps are removed first at areas of subsequent cuts and zero markers.

After removing stumps, the holes in fill and datum level contours are filled with earth, the destumped areas are plowed and the roots are removed by harrows or rippers.

The force needed for uprooting a stump depends on the nature of the tree, the time elapsed since the tree was felled, stump dimensions, the cohesion of the soil and, also, on the stumping method. The pulling force required for removal of stumps can, for approximate calculations, be taken from Table 1.

The spring period, when the thawed-out soil is highly moist and

TABLE 1

Пни (A)	B) Диаметр пней, см							
	15	20	25	30	35	40	45	50
	C) Тяговое усилие при корчевании пней в горизонтальном направлении, т							
Березовые . . D . .	2,5	5,5	7,5	9,5	12,0	16,0	20,5	21,0
Пихтовые . . E . .	2,5	5,0	7,0	9,0	10,5	16,0	18,0	20,0
Осиновые . . F .	2,5	5,0	6,5	7,5	9,5	10,5	15,0	16,0

A) Stumps; B) stump diameter, cm; C) pulling force for stump removal in the horizontal direction, tons; D) birch; E) fir; F) aspen.

also summer and autumn in the rainy period when the soil is moist, are most favorable for removing the stump's root system from the soil.

The composition of work involved in clearing the section from stumps includes pulling the stumps, their removal and extraction of roots which remain in the soil and filling the holes.

Stumps are removed by stump pulling and picking machines, stump pulling machines, bulldozers, stumping winches, tractor pull, specially equipped excavators and blasting.

<u>Stump Removal by Stump Pulling and Picking Machines, Stump Pullers and Bulldozers</u>

The D-210G stump pulling and picking machines (previously produced with the designation D-210V) and the D-210B and D-210A stump pulling and picking machines, whose technical characteristics are given in Table 2, are extensively used for clearing the construction area of stumps.

When performing stumping operations, these machines are capable of simultaneously delivering forces in the horizontal and vertical directions, which results in high outputs. The D-210G and D-210B stumpers are used for removing fresh stumps more than 25-30 cm in diameter. The D-210A stump pulling and picking machine is sued for stumping of medium and small size stumps.

To increase the productivity and improve the quality of work in

TABLE 2

A Основные технические характеристики	B Показатели по маркам корчевателей-собирателей		
	C Д-210А	D Д-210Б	E Д-210Г
Ширина захвата, мм F	3300	1475	1480
Высота отвала с зубьями, мм G	1950	1950	1900
Число зубьев, шт. H	8	4	4
Расстояние между центрами зубьев, мм I	400	400	400
Наибольшее заглубление отвала, мм J	540	5.0	400
Габаритные размеры с трактором, мм K			
длина L	5850	5850	5850
ширина M	3314	2874	2124
высота N	2760	2769	2769
Вес с трактором, кг O	13900	13950	13520

A) Basic technical characteristics; B) indicators for stump pulling and picking machine brands; C) D-210A; D) D-210B; E) D-210G; F) width of coverage, mm; G) height of blade with teeth, mm; H) number of teeth, pieces; I) distance between tooth centers, mm; J) greatest depth of penetration of blade, mm; K) overall with tractor; L) length; M) width; N) height; O) weight with tractor, kg.

stump removal by the D-210G stumper, use is made of special root-cutting knives (designed by T.S. Borshchev), which are installed instead of the two extreme teeth on the stumper blade.

The root cutters are 100 mm longer than the standard teeth and are installed at a smaller angle with the horizontal, due to which despite low penetration by the [main] blade, they efficiently cut the roots thus facilitating the stumping work.

The team needed for stumping using a stump pulling and picking machine of three workers, made up of the tractor operator, assistant and helper. The average productivity when removing stumps 30-40 cm in diameter is 200-250 pieces per shift.

Work in dry valleys and swampy soil is done by the M-6 stump puller, which consists of equipment mounted on the DT-54 tractor.

Large stumps can be pulled by the K-1A machine, whose working element is mounted on an S-80 tractor and consists of two double-arm teeth and two collector teeth.

Stump pulling by a bulldozer almost does not differ from stumping by stump pulling and picking machines.

It is recommended that heavy bulldozers be used for stumping and light bulldozers be used for windrozing the stumps. The average productivity of a bulldozer is 200 stumps per shift.

Special fixtures, which are mounted on the bulldozer blade are used for increasing the productivity for high-volume work. These devices include the stumping hoe and stumper. The designs of these devices are simple and they can be made in the construction site workshop.

The stumping hoe is comprised of a sharpened steel strip 35-90 cm wide and weighing 150-360 kg, mounted in the middle of the bulldozer blade. First, the sharp edge of the hoe undercuts the stump roots at a depth of 25-30 cm and then, the hoe is lifted and is used for pushing the stump. The stump is overturned and pushed away by the forward motion of the tractor.

The stumper consists of four cutters fastened to the pushing frame of the bulldozer. The extreme cutters serve to destroy the root system of the stump. For this purpose, their forward edges are provided with vertical blades. The wedge-shaped two middle teeth extract the stumps. The equipment productivity is up to 300 stumps per shift.

Stump Removal by Stump Pulling Winches and by the Tractor 11

When the work volume is large, the use of winches in stumping operations has a number of advantages in comparison with stump pulling machines. When stump pulling by winches, it is not necessary to drive over to each stump and a considerable area can be cleared from a single stand A winch equipped with a working cable 180-200 can clear an area of up to 5-7 hectares. In addition, the winches are used for collecting stumps into piles.

The tractor with a winch is placed at a section from which a maxi-

mal number of stumps could be pulled without change in position. The emplacement is cleared of undergrowth, small stumps and brushwood. When pulling stumps more than 35-40 in diameter, the tractor with the winch should be fastened to a strong stump by a short cable. When pulling large stumps and stumps of recently felled trees, the pulling cable is connected to a short cable by a system of transfer pulleys. The team consists of 4-5 people, i.e. the tractor operator and 3-4 helpers.

Stumps are removed by tractor pull when the work volume is small and when no other equipment is available. The cable used here is 10-12 meters long and 20-25 mm in diameter and, upon completion of work, it should be stored in a dry place and lubricated.

When pulling stumps by excavators, use is made of all kinds of stumping grips, which are installed instead of the other working equipment. Excavators, in addition to stumping, can be used for shaking the soil of the stump roots and also for windrowing the uprooted stumps of, for loading them onto transportation facilities. As a result of mechanization of several processes, the productivity of excavators in stumping work is much higher than that of other stumping machines.

Stump Blasting

The method of stump removal by blasting can be used at any time of the year, but it is most effective during the winter and when the section contains stumps more than 35 cm in diameter.

The blasting method is simple, its productivity is high and does not require complex equipment. When the work is properly organized, the stump is removed completely. The effect of the explosion depends on the weight of the charge, the depth at which it is planted and the property of the wood.

For removing the stump, the charge is placed beneath its center at a depth of 1-1.5 stump diameter from the earth's surface (Fig. 4). A

soil layer not less than 20 cm thick should be left between the stump and the charge.

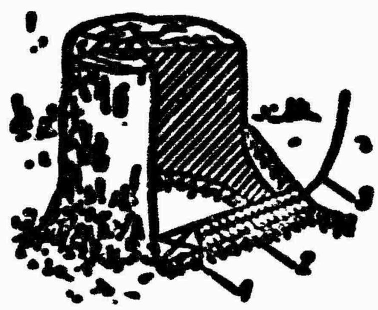


Fig. 4. Scheme for placing the charge. 1) Charge; 2) packing; 3) detonating pipe.

A blast hole up to 10-12 cm in diameter is drilled for the charge and not more than 1/3 of its length should be charged. If the charge cannot be contained in a single hole, then two holes are drilled. The charge should adjoin the core root.

The amount of the explosive charge for stumps of freshly felled trees is calculated by the formula

$$C = qD,$$

where C is the weight of the charge, grams; q is the amount of charge per linear cm of the stump diameter and D is the cut ciameter of the stump, cm.

Approximate values of q for standard strength explosives are given in Table 3.

TABLE 3

A Порода древесины	B Типы грунтов		
	C болотистые	D песчаные	E глинистые с примесью чернозема
	F Ориентировочная норма расхода ВВ для пней свежей срубки q, г		
Ель, ольха . G	13.5	14.0	12.0
Сосна . . . H	16.0	22.0	13.0
Береза, липа . I	17.0	23.0	14.0

A) Kind of wood; B) soil types; C) marshy; D) sandy; E) clayey with mixture of black soil; F) approximate norm of consumption of explosives for stumps of recently felled trees q grams; G) spruce, alder; H) pine; I) birch, lime.

The blast holes are drilled by electric drills and light-weight pneumatic drilling hammers.

Electric drills EBR-1 and EBR-2 are recommended for drilling holes

in frozen and loamy soils, while BM-17 perforators should be used in moist and sticky soil. Good results in drilling blast holes in frozen soil are obtained by using an attachment to the OMSP-5 jack hammer. The jack hammer blade is partially flattened out and split in half. Then, the ends so produced are inserted in a slit made for this purpose in a section of steel pipe and are welded to it.

When the work volume is small, the blast holes can be drilled manually. Drilling in frozen soils is most expediently performed by using a jumper borers or heated crowbars.

Standard strength explosives, such as TNT, ammonite, 62-percent dynamite, etc., are used for stump blasting.

Due to its simplicity, the fire method for detonating explosive charges is the most widely used of all available methods.

Prior to commencing stump blasting operations, a table of charges is drawn up in accordance with stump diameters. Then the blaster determines the amount of explosive from the table for each stump diameter and records this amount in chalk or paint on the stump, in grams, prepares charges of the required weight and places them in the blast holes. In order for the explosion to be effective, after the charge is placed, the hole is thoroughly packed with dry sand or thawed dense soil. The length of the firing cord is determined, so that the blaster can ignite it from a safe place.

The length of cord for that stump which will be detonated first is 150 cm, this being decreased by 5 cm for each succeeding stump. The cord length for the stump detonated last, should not be less than 100 cm.

After 10-15 stumps have been prepared, a signal is given for the blasters to ignite the firing cord. The number of blasters is determined depending on the distance between stumps, the distance from shelter and the length of firing tubes.

The stump blasting team consists of 5-6 workers in the summer and up to 8 people in winter. The average output is up to 200 stumps per shift.

When performing blasting operations, the basic rules of safety must be strictly observed:

1. Only trained workers are permitted to perform blasting work.

2. The stump removal section is surrounded by poles, or fenced off by red flags with appropriate signs. Signs with warnings should be placed at all paths and roads leading to the blasting site.

3. The beginning and end of operations is determined by order or signal from the chief. Before charging a signal is given which requires everybody to seek shelter, or to move away to a safe distance, i.e. not less than 250 meters. After charging ends, another signal is given and the firing commences.

4. It is prohibited to set fire to a cord which was once ignited, but then extinguished.

5. The blaster should keep a record of the explosive charges. If any charge did not detonate, then only the senior member of the team may approach it and this, not earlier than after 15 minutes after the standard detonation time.

6. Smoking when working with explosives is prohibited.

7. Special instructions must be followed when performing blasting operations.

Removing Stumps and Breaking up Roots which Remained in the Soil

The pulled out stumps are collected in windows and piles and hauled away. Prior to removal, the soil stuck to the stump's root system should be shaken off. This is a difficult and laborious process.

When the pulled out stumps are piled by the M-6 machine, or by the TSB-3 brush collector (designed by T.S. Borshchev), a large part of the

soil is shaken off and further removal of it from the stumps requires little effort. When dragging away stumps, the forward girder of the pushing frame of the M-6 machine is equipped with six teeth. Extensive penetration by teeth is prevented by skis fastened to the lower edges of the teeth. The width of the working coverage of the M-6 machine using 6 teeth, is 3 meters.

When piling the stumps, the M-6 machine or the brush collector at the same time also uproot small stumps and individual bushes. The brush collector's root cutters, which are sunk to 10-15 cm, additionally brake up large roots. Several passes of a brush collector break up very well any roots remaining in the soil at a depth of up to 15 cm.

The roots can be removed from the soil by angular (zig-zag) passes of the D,162 ripper.

The uprooted stumps are piled into windrows and piles by stump pullers and pickers, bulldozers, the M-6 machine or the TSB-3 brush collector. When stumps have to be moved through a large distance, they are hauled away on sledge scrapers, or special tractor-drawn trailers with a low body.

4. LOGGING AND HAULING AWAY THE TREES

General Characterization and Logging Methods

The land area assigned for an airfield can contain large wooded areas which should be cleared. Trees situated in the path of air approaches and which are obstacles in take-off and landing of aircraft, are felled.

Trees are <u>first</u> cleared from the construction site and then from the path of air approaches.

Prior to commencement of work, the locality is thoroughly studied to determine the density of trees, their species and diameters. Classification of forests by their size and density is given in Table 4.

The following methods may be used for clearing the area of trees:

TABLE 4

A	B				
	C	D	E	F	G
	H				
I	[illegible]	[illegible]	[illegible]	1400	[illegible]
J	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
K	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

A) Forest density; B) forest characteristics; C) large, d = 32 cm; D) medium, d = 21-31 cm; E) small, d = 16-23 cm; F) very small, d = 12-15 cm; G) thin trees, undergrowth and brush; H) number of trees per 1 hectare, in pieces; I) dense; J) medium; K) thin.

sawing off the trees with subsequent pulling of stumps;

felling the trees with the roots [uprooting].

The choice of a method depends on a number of factors, primarily on the species and diameter of trees, forest density, work schedules and the availability of equipment. Uprooting of trees requires less force, since the weight of the tree trunk and top will facilitate the uprooting of the root system. It is difficult to uproot densely growing trees, while they can be sawed off, this being true not only of sections with densely growing trees, but also for trees of any diameters and species. It is expedient to cut trees when clearing the air approach strip, which does not require subsequent pulling of stumps. Cutting the trees off, preserved serviceable timber, which is used subsequently for building purposes.

Cutting off of Trees with Subsequent Pulling of Stumps

Operations for cutting off of trees with subsequent pulling of stumps, consist of sawing off the trees and hauling away the timber, pulling and hauling away of stumps and extraction of roots from the soil and filling the holes.

The trees are sawed off in a predetermined sequence, starting with

preparing the working place and choosing the direction in which the tree should fall. The tree should be notched on the side toward which it should fall, then cut through from the other side (Fig. 5).

Light portable mechanical saws (chain, electrical and gasoline engine) are most extensively used for sawing off of trees. Hand saws can be used only when the work volume is small and for cutting of trees with a diameter up to 25-30 cm.

Gasoline motor saws "Druzhba" and "Ural" and electric saws of the TsNIIME KB-2 type are extensively used. The "Druzhba" saw is capable of felling a tree of any diameter. The fact that it is supported at one end, makes it possible to operate by its second end and to fell trees with a diameter which is twice larger than the working length of the blade. The "Druzhba" has high operational indicators and is simple in operation. The average productivity in terms of the area cut through, is 30 cm^2/sec (for diameters of 45-50 cm).

The sawing apparatus can be positioned for horizontal (felling of trees) and vertical (cross-cutting) cuts.

Electric saws are used for continuous sawing. The use of an electric saw for selective cutting on small sections where a part of the timber was removed, is not expedient.

The power for electric motor saws is usually supplied from a portable electric power station, or from the standard electric network. One PES-15 electric generator can supply 3-4 saws. The current is supplied from the electric power generator by main and saw cables.

Undernotching and sawing is sufficient for felling a tree in the direction of its natural slope and, if it is necessary to fell the trees in the opposite direction, the notch is insufficient and an additional force is required for turning the tree over. A tree felling lever, or a special fork, is used for this purpose.

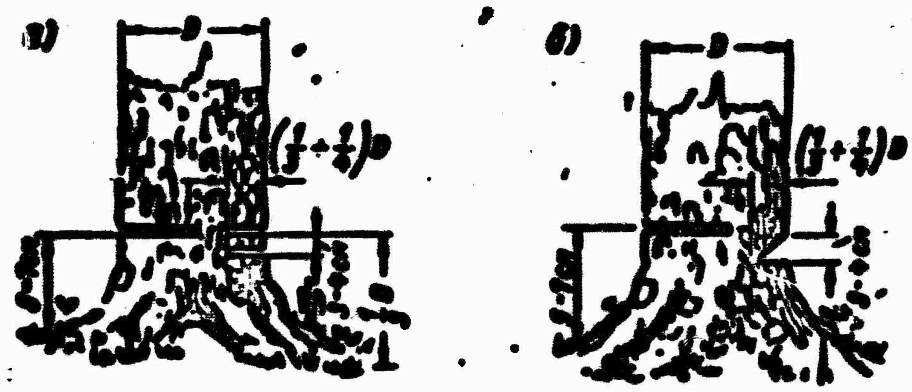


Fig. 5. Methods for undercutting (notching) of a tree: a) ouble horizontal cut; b) a notch at an angle.

Wind increases very sharply the force required for felling a tree and, for this reason, work for felling trees against the wind direction is ceased even when the wind is weak. The felled trees can be hauled away from the airfield area immediately, or after the branches are cut off.

Loop type branch cutters designed by Belyayev and Osokin are an effective facility for mechanization of branch removal. Electric branch cutters TsNIIME, RES-1 or the disk-type electric branch cutter "Sever" can be used.

The tree cutting team consists of 6-8 workers, including the saw operator and his assistance, a notch cutter, pusher and 3-4 helpers, which chop off and collect the branches. For manual felling, the team is increased to 10-11 people.

Saws mounted as equipment on excavators and crawler cranes, which not only cut off the trees but also pile them or load onto trailers, are distinguished by their high productivity. For cutting of trees with trunk diameters greater than 15 cm, the earth digging equipment on the excavator boom is replaced by a disk saw and timber stacker. The disk saw cuts the trees by being continuously revolved by the boom (similar to scythe strokes), which the stacker then places in a windrow behind the unit parallel to the direction of motion, in piles placed in the di-

rection of motion.

This group of machines includes the BPM-TsNIIME felling and loading machine, with an average output up to 100 meters^3 per shift (for an average tree volume of 0.4 meters^3).

The felling and loading machine, thus ensures ordered hauling off of timber from the logging sector.

The following <u>basic safety rules</u> must be observed when working with mechanical saws:

1. Persons permitted to operate mechanical saws must have special training in the rules of setting-up and operating the saws and also in safety rules when operating them.

2. Before work starts, the state of tools and accessories must be checked.

When working with electric saws, the grounding is checked at the cable joint and the station.

3. The sector should be marked by signs with the warning: "Caution. Logging Operations."

4. The work should start with felling sharply bent, dry and overhanging trees.

5. Unauthorized persons are not permitted to enter the work sector.

6. During operations and when carrying over, when the electric saw is connected to the circuit, it should be held by the handle only; touching of metal parts of the saw with [bare] hands is forbidden.

7. It is forbidden to carry over electric saws when the motor is working.

8. The electric saw must be in a stable position before the electric motor can be switched on.

9. When the saw chain falls off the busbar, the motor is immediately switched off.

10. After work is finished, the saw should be disconnected from the power line.

11. When working with electric saws, use must be made of individual protective facilities (rubber boots, gloves, mats).

When working with gasoline motor saws, it is forbidden to start the motor with the saw chain engaged, overfill the tank with fuel, smoking when priming the motor.

Felling of Trees with Roots

Felling of trees with roots is the most extensively used method for clearing an area of trees. Trees together with roots can be felled by the blasting method, by stump pullers and pickers and bulldozers, by tractor pull and by stump-pulling winches.

The blasting method is most expedient for use in the winter for felling large and medium sized timber and, also, during the summer on dry and hard soils. The size of the explosive charge is determined by test blasting of trees of different species on soils of differing character. The charge size for standard power explosives can be approximately taken as equal to 8-15 grams per 1 cm of tree diameter. The fact that less explosives is consumed here than in blasting of stumps is due to the fact that here the roots are additionally twisted off by the weight of the falling tree. To preserve the tree trunk, the explosive charge is placed at a depth not less than 0.5 meter from the surface.

Trees, when felled, fall in the direction of natural slope under the weight of their top and, for this reason, cases are possible when trees do not fall on a free area but are held back by the tops of standing trees. These hanging trees must be immediately removed, since unexpected falling, for example under the action of wind, can result in accidents.

The methods for felling of trees by stump pulling and picking ma-

chines and bulldozers differ little from stumping operations. When felling large trees, the lever arm for overturning is increased by having a bulldozer make an earthen ramp with a slope of 0.2 at the tree trunk and fell the tree while standing on it.

The productivity of bulldozers and stump pulling and picking machines for average density of trees is up to 1 hectare per shift.

Trees are felled by tractor pull in those cases when other equipment is not available and the work volume is small. The auxiliary equipment for the tractor consists of a steel cable 20-25 mm in diameter and not less than 50 meters long (so that its slope angle should not exceed 25-30^{o}). One end of the cable is fastened to the tractor and the other is tied to the tree being felled. The cable is fastened to the tree at a height calculated, so that the trunk will not break (from 1 to 2.5 meters, depending on the diameter and species of the tree). If the tree does not fall after 2-3 cable pulls, then the thick roots at the side opposite to the felling direction should be undercut. The crew for tractor felling of trees consists of 4-5 workers. Its productivity is up to 50-60 trees per shift.

The comparatively moderate productivity of this method is due to the large amount of time required for fastening the cable. The time for fastening the cable can be cut by felling a number of trees at a time.

After trees are felled and the branch stumps cut off, the tops and roots are cut off, the trunks hauled away from the logging sector and cross cut, if necessary. The trunks are hauled away by hauling tractors, or by ordinary tractors with subsleighs. The hauling tractor has a higher passab'lity and, for this reason, can operate on marshy sections.

5. REMOVAL OF STONES

Large areas littered with stones are found in the nonblack soil belt of the USSR, especially in its northern and north-western regions.

In a number of cases, it is necessary to remove up to 150-200 $meters^3$ and more from one hectare.

The stones can be strewn about on the surface, partially protrude or be concealed in the upper layer of the soil. When constructing airfields, stones should be removed from the field at sections designated for cuts; at fill sections, when the planned fill height is up to 1.0 meter; on the route of the water disposal network; at sections with zero markings, when the stones are located at a depth not less than 0.5 meters.

By their size, stones are conventionally divided into boulders with a diameter of more than 1.0 meter, large stones - from 0.6 to 1.0 meters, medium - from 0.3 to 0.6 meters and small - from 0.07 to 0.3 meters.

The stones can be extracted and cleared by various stump pulling machines. The D-210V stump pulling and picking machine, the KR-6 stump puller, bulldozer and also the D-162A ripper are most frequently used for extracting stones.

Large stones, 1.8-2.0 meters in diameter, which cannot be uprooted, must first be blasted down to size.

As a rule, the stones are broken up by charges placed in grooves. The amount of explosives used, comprises from 100 to 500 grams per 1 $meter^3$ of stone. When breaking up by external charges, the consumption of explosives increases to up to 2 kg per 1 $meter^3$ of stone.

Stones extracted from the soil and lying on the surface should, as far as possible, be immediately removed from the airfield site so as to allow for succeeding operations.

Stones with volumes up to 2.5-3.0 are hauled away from the airfield site by special scrapers which are made from sheet steel 8-10 mm in thickness in the on-location workshop. The dimensions of a scraper in

the plane for coupling to the S-80 (S-100) tractor are approximately 5.0 x 3.0 meters and for work with the DT-54 tractor, the dimensions are 3.5 x 2.5 meters.

Stones are conveniently loaded and unloaded from the scraper by a bulldozer, or a stump pulling and picking machine. A scraper pulled by the S-80 tractor is capable of hauling up to 5.0 meters^3 of stones, while the capacity of the scraper pulled by the DT-54 tractor is up to 3.5 meters^3. Long distance hauling of stones is performed by tractor trailers, trucks and sledges. Stones are loaded and unloaded by T-92 and T-75 tractor mounted cranes, or by T-106 general purpose tractor units, equipped by special gripping devices.

Previously dug-out large stones can be hauled away over a short distance, by simple chain and cable devices.

When the work volume is small, it is permitted to haul away stones over a distance up to 50-70 meters by a stump pulling and picking machine or bulldozer. When transporting large stones, the blade should be kept in the half-lifted position, so that the teeth do not touch the ground. When transporting small stones, the blade is lowered to touch the soil surface, but care is taken that it should not dig into the soil.

In individual cases, it is permitted to bury large boulders on the spot. Here, the top surface of the stone should be, at least, 0.3 meters below the design airfirle surface. This method cannot be used at sections designated for paving, water discharge network and other communications.

6. CLEARING THE AREA OF BRUSHWOOD AND SMALL TREES

Work for clearing of brushwood and small trees is mainly encountered in constructing airfields in the nonblack soil belt of the USSR. Sections with standard moisture content are overgrown by gray alder with a small admixture of birch, aspen, willow and spruce, while sections with excessive moisture content are overgrown by willows. Strongly pod-

solized sandy and fine clay soils (with standard moisture content), are frequently overgrown by bushes of juniper, birch, willow, gray aspen and other species.

Machines used in clearing a site from brushwood, operate under very difficult conditions; the load on the working element is variable, fluctuating within wide limits; for this reason, the machines should have increased strength.

Operations for clearing an area overgrown by brushwood, consist in cutting off the brushwood and small trees and in raking together the sawed-off brushwood and clearing the soil surface of roots and small stumps.

Brushwood growing at the site of the air approach strip, is only cut off, since the other operations are unnecessary.

Brushwood and small trees are cut by brush cutters, whose working element consists of a knife. Brushwood can also be removed by chemicals.

The D-174V brush cutters are usually used. It is also possible to use a marsh meadow brush cutter mounted on the DT-54 tractor, or a brush cutter with a hydraulic drive mounted on the S-100B marshland tractor.

The D-174V brushcutter (Fig. 6) is used for cutting of brushwood and saplings up to 15-20 cm in diameter in dry valleys.

Large stumps, trees and other obstacles should be first removed by stump pulling machines, since they interfere with normal operation of the brush cutter. If these obstacles cannot be removed, then they are marked by markers so as to permit the tractor drive to avoid them.

Brushwood clearing starts with placing the brush cutter in the desired direction at the boundary of the site. Here, the knife should be lowered to the required depth.

The basic requirement put to the quality of the brush cutter's work is that the brushwood be cut low and evenly. With this as the starting

Fig. 6. Cutting brushwood by the D-174V brush cutter.

requirement, the brush cutter knives should be lowered so that they touch closely the soil surface. In sapling overgrowth with tree trunk diameters of 7-10 cm and more, a clearance of about 1.5-2.0 cm should be left between the soil surface and the brush cutter blade. At sites containing a large number of small stones strewn about on the surface, the brush cutter knives should be lifted 3-10 cm from the soil surface in order to avoid breaking the knives. If the trunk diameters do not exceed 5-7 cm, then the site is cleared in second gear, using both brush cutter knives. In this case, after one strip has been passed, the second is started at such a distance from the first, that the brush cutter can work with both the right and left knives leaving a pile of the cut-off brushwood and saplings in the area between passes. The width of a strip cleared in a single pass by the D-174V brush cutter is 3.5 meters.

At sites overgrown by aspen, fir and birch with trunk diameters of 4-10 cm, a single brush cutter pass cuts off almost the entire brushwood, Brushwood which has not, thus, been cut off is trampled by the tractor crawlers and the brush cutter skis.

Sites overgrown by alder and willow, creeping on the ground, are cleared from a direction opposite to the slope of trunks. In order to completely cut off the brushwood at this section, a second brush cutter pass from the opposite direction is needed.

When working with small brushwood (trunk diameter less than 4 cm), complete cutting is achieved only after two passes, since the uncut part of brushwood straightens up after the first pass.

If the diameter of tree trunks is greater than 7-10 cm, then the section is cleared in first gear and using only one brush cutter knife. It should be taken into account in this work, that the cut trees by exerting a resistance to the brush cutter knife, displace it from the preset direction.

Trees 25-30 cm is diameter which are encountered at the section, cannot be cut by a single pass which necessitates several passes, thus sharply lowering the brush cutter productivity.

Dry valley sections can be cleared by brush cutters for a snowfall up to 40-50 cm. Good quality cutting of brushwood is achieved in the early spring, when little snow remains, while the soil is still frozen and during the winter, when the brushwood trunks are securely fastened in the frozen soil.

The quality of the brush cutter work depends, to a large extent, on the sharpness of the knives. A blunt knife does not cut the brushwood, it only bends it underneath. Care should be taken to provide each brush cutter by a mechanical sharpener for the knives.

Depending on local conditions (the relief, dimensions and shape of the section), the brush cutter operates according to the following schemes:

circular (from the section edges to its center);

by strips;

from the middle of the section;

in a shuttle pattern.

Brush cutter operation using the circular scheme (Fig. 7, a) is simple and convenient. It is used on large sections of regular shape with a mild topography. The work is started from the section's edges and, driving along its perimeter, till the middle is reached. The disadvantage of this scheme is the fact that with each successive pass, it be-

comes more difficult to turn the brush cutter, which necessitates spending time on fancy turns.

Work, according to the strip scheme (Fig. 7,b), has the advantage that the turning radius of the brush cutter remains constant.

The scheme according to which work starts from the middle of the section (Fig. 7,c), is used when the section is situated at a watershed. The disadvantage of this scheme is the fact that the brush cutter must execute sharp turns at the beginning of work.

The shuttle pattern scheme (Fig. 7,d) is used when clearing brushwood from hillsides. The passes of a brush cutter working according to this scheme, should be situated across the hillside slope (along the horizontals of the locality).

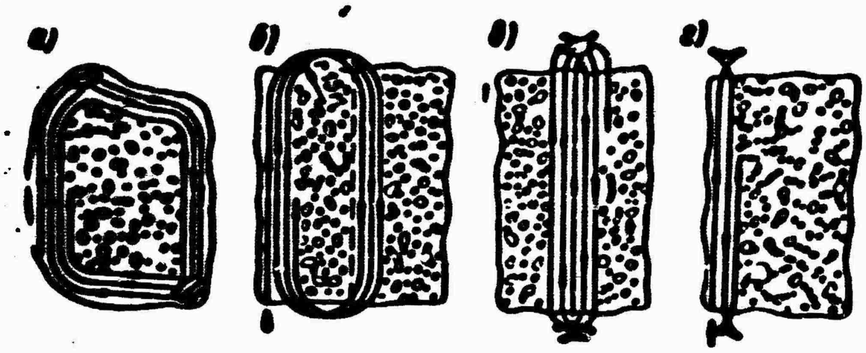


Fig. 7. Schemes for the brush cutter movements in clearing sites.

The direction of brush cutter passes, using any of the enumerated schemes, should be changed before the cutting starts. Maneuvering the brush cutter on overgrown sections is difficult, for which reason cross-cuts 7-7.5 meters wide for turning the brush cutter around (for backing out), should be provided at the edges of sections being cleared.

$$\Pi = \frac{bv\left(k_v - \frac{n_1 t_1}{60}\right)}{10 n} \text{ hectares per shift}$$

where b is the width of coverage, meters; v is the working velocity of the brush cutter, km/hour; t is the duration of the working shift, hours; k_v is the working time utilization coefficient; n_1 is the number of

turns at the edges of the section; t_1 is the time used up per one turn, minutes; n is the number of passes over the same trace (1-3).

When the section contains individual large trees, a correction is made in the formula for the time used up in cutting these trees.

The crew for brushwood cutting consists of 2-4 workers, including 1-3 helpers, which clear the brush cutter from trees which fall on it, take care that they do not get stuck in the crawlers, etc. The number of helpers depends on the character of the locality and on the time of the year.

The average productivity of the D-174V brush cutter is up to 6.0-8.0 hectares per shift (for trunks 4-6 cm in diameter).

Observations of the work of passive action brush cutters have shown that they require considerable design improvements. Active action brush cutters, whose working element, in addition to the rectilinear motion together with the tractor performs also forced motion, are more productive. Experimental specimens of active action brush cutters were built on the basis of the "Belarus'" tractor.

After the brushwood is cut, it should be collected. The GKN-3 brushwood harrows and D-210A stump pulling and picking machines are used for this purpose.

The GKN-3 brushwood harrows are mounted on the DT-54 tractor. Their working element consists of five teeth of welded design, made from angle steel and rigidly fastened to skis which create a sufficient bearing surface for the harrow during the work. The width of the harrow coverage is 3000 mm. The choice of the direction of working passes by brushwood harrows and stump pulling and picking machines depends on the dimensions of the section, number of cut growth and conditions under which the work is performed. The direction of harrow passes, as a rule, should coincide with the direction of the brush cutter motion.

After the brushwood has been raked together, the soil can be plowed by a marsh-brushwood plow, if this is necessary.

Small stumps and roots must be especially thoroughly removed from sections to be used for runways, taxiways and stand-by aprons, since timber rotting in the soil will result in nonuniform settling and any remaining roots will interfere with proper soil compaction.

Small stumps and roots can be removed by a bulldozer, equipped with forward-bent teeth, which gives a 30° cutting angle and a loosening depth of up to 12 cm. The average productivity of a bulldozer in removing roots, is 10-12 hectares per shift.

The stump pulling and picking machine can independently perform all the technological operations involved in clearing the airfield site from brushwood, namely, cutting the brushwood, windrowing it, and clearing the soil of the root system.

The productivity in clearing the brushwood manually is extremely low and this is permitted only at those places where machines cannot be used.

The following safety rules must be observed in clearing sections of brushwood and saplings:

1. Persons assigned to driving the brush cutter must be specially trained and must have passed minimum technical knowledge examinations about brush cutter operation.

2. Prior to commencing work, the brush cutter should be inspected and all malfunctions corrected.

3. It is forbidden to:

a) leave the brush cutter with the engine running;

b) work with a brush cutter with defective guards;

c) repair the bush cutter in motion.

4. The helper crew should be at least 25-30 meters away from the

brush cutter.

7. BREAKING UP OLD PAVEMENTS

Airfields which were paved before 1945, were basically designed to handle aircraft with a flight weight up to 50 tons.

Developments in the field of jet power and increasing the flight weight of aircraft, have made it necessary to increase the runway length and the pavement strength. For this reason, existing airfields are rebuilt together with construction of new airports. In rebuilding airports and also in repairing runways, it becomes necessary to break up individual sections of the old pavement. This most labor consuming work should be completely mechanized.

Pavement can be broken up by the D-162 heavy ripper, special tractor-mounted equipment, concrete breaker and weight-dropping hammer. The D-162 ripper can be used for breaking up simple, refined and also permanent asphaltic concrete and cement concrete pavements.

When breaking up pavements made of macadam, gravel and from bitumen treated materials, the ripper is provided with one or two bars, which are lowered to the required depth and which, during the tractor's motion, break up and loosen the pavement on 1-2 passes over the same run.

For breaking up concrete pavements (also here the ripper is equipped with one or two bars), the ripper with the lowered bars is brought under the edge of the pavement being broken up, the ripper frame is lifted and the pavement is broken up by the forward motion of the tractor (Fig. 8).

The D-107 loader and specially equipped bulldozers are successfully used for breaking up old asphaltic concrete pavements. For this purpose, the standard bucket of the D-107 [sic] loader is replaced by a massive bucket whose forward lower edge is equipped with knives and five

replaceable teeth, which are situated ahead of the cutting edges of the knives. Depending on the thickness of the pavement being broken up, use can be made of straight teeth and of teeth with a cutting ridge, or with a breaking projection.

When asphaltic concrete pavement is to be broken up by a bulldozer, its blade is provided with a special attachment - a three-toothed device designed by S.A. Astaf'yev (Fig. 9). The attachment consists of a steel plate 35-40 mm thick, with three steel teeth with a cross section of 90 x 90 mm and 500 mm long mounted on it and of two vertical cutting ribs. The teeth are brought in beneath the pavement and break it up. The productivity of this asphalt breaker is up to 1400 meters^2 per shift.

Concrete cement pavements with thicknesses up to 30 cm and more, are broken up by the D-198 concrete breaker, which is mounted on the chassis of the MAZ-200 truck. The pavement is broken up by several strokes of a pneumatic hammer, until a crack is formed, whereupon the hammer is placed in a new position by revolving the frame.

The average productivity of the concrete breaker:

for a concrete plate thickness of 20 cm . . . up to 45 meters^2/hour

" " " " " " 30 cm . . . up to 15 meters^2/hour

Concrete plates up to 40 cm thick can be successfully broken up by truck cranes (excavators with crane equipment), with a weight-dropping hammer, weighing not less than 1.0-1.5 tons and with a falling height of from 3.5 to 5.0 meters. It is recommended that a sphere shaped weight be used. Concrete pavements, more than 40 cm thick, can be broken up by blasting, by charges placed in blasting holes, or by externally placed charges.

Pneumatic and electric tools serve as auxiliary equipment in breaking up asphaltic concrete and cement concrete pavements. Old concrete

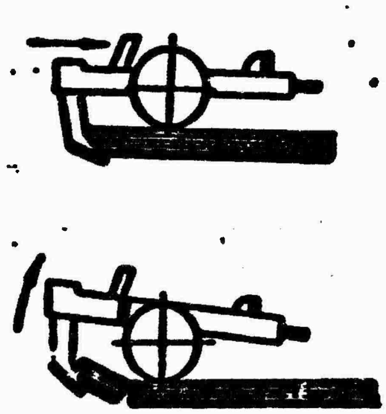


Fig. 8. Scheme for breaking up of concrete pavement by the D-162 ripper.

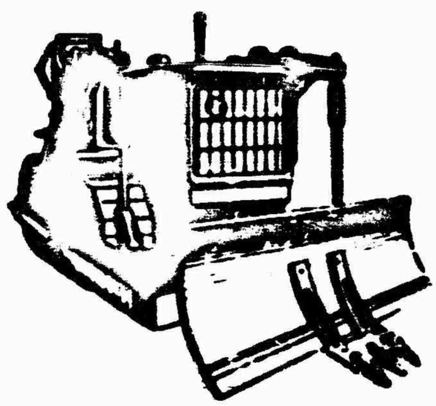


Fig. 9. The D-149 bulldozer with mounted equipment designed by S.A. Astaf'yev.

pavements can be removed without breaking them up, if they consist of small plates with through seams.

8. REMOVING EXISTING STRUCTURES AND UTILITY NETWORKS

The list of structures subjected to removal is established by the plan and is included in the preparatory work plan.

Operations for removing and carrying over structures, roads, electric power lines, etc., are performed first and agreement for their implementation should be obtained from the interested institutions and organizations.

It is expedient to transport moderately sized wooded structures without dismantling. Special carts (house movers) are used for moving wooden building situated on the airfield site.

The building is placed at its new location on a previously prepared foundation.

All elements of wooden structures being dismantled should be marked first.

If the structure is old, it is dismantled and the material is used for construction purposes. Large structures (for example, a two story building), are dismantled according to special plans.

In building and also in rebuilding airfields, it becomes necessary to remove and move over communications and power supply lines.

First, the new bypassing communications (or electric power) line is built and only after it becomes operational, is the existing line dismantled.

An act about moving over communications or electric power lines is made up in the presence of representatives of those institutions, organizations and enterprises, which are in charge of these lines.

9. PRELIMINARY DEWATERING OF CONSTRUCTION SITES

Earth digging and other machinery may find it impossible, in a number of cases, to work on muddy sites. For this reason, the main operations for constructing an airport should be preceded by dewatering of excessively moist sections. The dewatering method is determined depending on the type of the water fee, soil conditions and on the relative moisture content of the section.

The cause of excessive moisture can be surface waters, or closely lying ground waters. If the excessive moisture is caused by surface water, then the section is dewatered by draining the water away. When the ground water level is too close to the surface, it is lowered.

Preliminary dewatering the construction site not only ensures productive work of machines performing the main airfield construction operations, but also stability of pavements and fills on the ground part of the airfield.

Drainage of Surface Water

Surface water is removed by building an open drainage network, which consists of auxiliary ditches which collect water from low-lying areas, flow ditches, main channels and drain reservoirs. Lakes, rivers, streams and ravines located outside the airfield limits, usually serve as drain reservoirs. Permanent drainage accumulators and collectors can also serve as drain reservoirs. In a number of cases, pumps are used to move the water from deep depressions to the ditches. In addition, depending on the relief of the locality, mountainside ditches are also built.

Auxiliary ditches are small and narrow furrows whose bottom is

slanted in the direction of the flow ditches.

The flow ditches should be not less than 0.6 meters deep for slopes with grades of 1:1,1:1,5.

The main ditches are usually from 1 to 3 and more, meters deep. When a large quantity of water is drained, the ditch cross sections should be calculated by hydraulic engineering methods. Main ditches are dug by excavators with outsized crawlers.

The ditch network is staked out by aligning the future ditch along the axis which is placed on the side and by staking out at the beginning and end by type II monuments (see Fig. 1). The course of the ditch system should have the smallest possible number of sharp breaks in the plane. To decrease the amount of work necessary to a minimum, ditches dug in horizontal sections are graded with a 0.001-0.002 slope, while the natural slope of the locality is followed where such exists. Auxiliary ditches are graded directly at the locality with their bottoms sloping in the direction of the flow ditch.

The route of the temporary drainage network elements should, as far as possible, be made to coincide with the route of the permanent draining network for runways, taxiways and aprons. In this case, the ditches are not dug to full depth, but to not less than 0.5 meters higher than the design depth of the permanent drainage network.

Flow ditches are dug by the KM-1400, LKA-2 and other plunger type ditchers. The KM-1400 and LKA-2 ditchers are used for digging of ditches in ordinary and peat soils, free of large stones. A ditcher with two S-80 tractors can open a full profile ditch in a single pass. If the ground is not excessively moist, the ditches are dug from the discharge side.

The ditchers are coupled to tractors which move one after the other. When working in extremely moist soil, the digger is coupled to two trac-

tors. The output of plunger ditchers is up to 1.2 kilometers/hour.

Lowering the Level of Ground Water

The airfield plan usually provides for a permanent draining system for lowering the ground water level.

The drainage rate, during the construction period, is several fold faster than when the airfield is fully operationa, for which reason the preliminary drainage network is by a factor of 3-4 less dense than the planned permanent drainage network.

The ground water level lowering prior to earth moving work should, thus, be accomplished by constructing a part of the permanent drainage network. When the permanent drainage network is very deep, preliminary drainage can be achieved by constructing an open drainage network.

Drainage ditches are dug parallel to the direction of soil displacement from a cut to a fill. If this direction coincides with the direction of permanent drains, then the ditches are made to coincide with the route of the drains, but are dug so that not less than 30 cm of soil remains from their bottoms to the design bottom of the drain.

Construction of open ditches for lowering the level of ground water creates considerable difficulties in performing the main work and their use is permitted [only] if timely construction of the deep drainage system is difficult.

A permanent team of workers should be assigned to maintain the temporary water discharge system. Water cannot be left standing in the ditches, for which reason they should be periodically cleaned.

After the earth-moving operations are finished, all ditches which will not be subsequently used in constructing the permanent network, are filled. When filling, the soil must be thoroughly compacted layer by layer.

Chapter 2

EARTH MOVING OPERATIONS

10. GENERAL CHARACTERIZATION AND COMPOSITION OF EARTH MOVING OPERATIONS

Safe take off and landing ofaaircraft and also ensuring natural runoff of precipitation requires that the airfield surface be level, have specified grades and radia of curvature.

Sites chosen for the building of an airfield are usually not level. The natural surface, as a rule, does not conform to engineering requirements put to the topography of airfield air strips.

The topography of an airfield is corrected by earth moving operations. Earth moving work is also performed in constructing the bed for runways, taxiways, aprons, in replacing nonstable soils (at sites covered with peat), in digging trenches and ditches of the water drainage network, etc.

Earth moving work at airports differ by their character from earthworks performed in hydraulic engineering construction, in constructing automobile highways, etc. The basic features of earth moving operations at airfields include:

a) the area character of the works distribution; here the distribution of earth masses over the airport area, as a rule, is not uniform; earthwork sections can be composed of large masses of cuts (fills) or of individual small contours with an insignificant volume of earth moved;

b) in making up the vertical relief plan of an airport, a balance

cut and fill volume are kept equal. This determines the methods by which they are produced; all the soil from the cuts, as a rule, is transported and deposited in the fills.

When the cuts and fills are adjacent, local balance of earth masses is kept, while if they are not close to one another, a total balance of earth masses is kept, i.e., the sums of earth volumes of all cuts and of all fills are balanced. It is very seldom that borrow areas are established outside the airfield limits for obtaining fill soil or that dump pits are provided for placing excessive soil, this is only done when it is expedient from the point of view of economics;

c) the inclusion, in the majority of cases, of operations involving preservation and restoration of topsoil, in the composition of earth moving operations.

Earth moving operations in airport construction are subdivided into volume, grading and topsoil operations.

<u>Volume earth moving operations</u> are performed when it is necessary to change the topography of the site, in constructing beds for runways, taxiways and aprons, and also in replacing unstable soils.

<u>Grading earth moving operations</u> are performed in order to bring the surface of the beds and the airfield, after volume earth moving operations have been completed, to the design elevations, and also for correcting the microtopography of the surface of sections at which no depth earth moving work was performed (at zero sections). Grading operations correct individual irregularities of surface not exceeding 10-12 cm in height.

<u>Operations with topsoil</u> are performed in order to preserve the topsoil for subsequent restoration on the unpaved part of the airfield, since the seeds of turf-creating grass grow faster in topsoil. The top-

soil is removed from the entire surface of the pavement bed and is not restored.

The earth moving operations consist of the following structural processes and operations:

loosening and breaking up the topsoil layer:

its removal, piling, and moving over to a new location;

loosening, quarrying and moving the soil into fills (the leading operation);

layer by layer leveling of the soil put into fills;

layer by layer compacting of the leveled soil;

rough (preliminary) grading of the bed and airfield surfaces;

final grading of the airfield (final grading of the sub pavement bed can be included in the composition of concrete [laying] operations);

rolling of cut sections and zero work sites (at bed sections, this operation can be included in the composition of concrete [laying] operations);

spreading of the topsoil over the airfield;

leveling and final rolling of the restored topsoil layer.

The character and volume of earth moving operations can be very varied and depend on the topography and soils of the site, the purpose of the airport, the dimensions of the grounds of the airfield (of runways, taxiways and aprons) with surfacing, etc. For example, in the construction of airports in the steppes regions a considerable proportion of work is devoted to grading operations, while in constructing them in the northern regions and mountaineous localities, volume earth moving operations predominate.

All kinds of earth moving operations belong to the most labor consuming and difficult airport construction operations and should be

entirely mechanized.

The Soviet machine building industry produces a sufficient number of high productivity machines for performing all kinds of earth moving operations.

Earth moving operations are performed by earth digging and grading machines.

Soils placed in fills and airfield surfaces are compacted by various compacting machines and equipment.

In addition to the mechanical method of earth moving, it is also possible to use the hydraulic method for loosening and removing it, i.e., the hydraulicking operation. Rocky soils are first loosened by explosives.

The varied earth moving techniques and equipment allow to perform the same operations using different machines. For this reason, proper selection of the method for mechanizing of earth moving operations and choice of machines, which best conform by their technical characteristics to the work conditions, must be preceded by checks and comparisons of technical and economic indicators of each machine.

In airport construction, as a rule, cuts are made in layers. This method can be used for any cut depth, and also when the soil layers are not uniform.

The facing method is used only in deep cuts (more than 1.0-1.5 meters) with uniform soil stratification in depth.

As wasshown by analysis of airport construction of the last few years, of the total volume of earth moving operations the following percentages were performed by

scrapers	65-70%
bulldozers	10-15%
excavators and other mechanization facilities	5-15%

The level of mechanization of earth moving operations increases continuously. Thus, in 1950, the mechanization level was increased by a factor of 1.5 as compared to 1943, and in 1961 the level of integrated mechanization of earth moving operations in airport construction has reached 98% of the total volume of earth moving operations.

Earth moving operations are mechanized by yearly assimilating the production of an entire series of new earth digging machines, including self-propelled scrapers, earth hauling carts, powerful bulldozers mounted on crawler tractors, self-propelled rollers, self-propelled vibratory plates, general purpose excavators and continuous action earth digging machines. In integrated mechanization of earth moving operations, special attention should be paid to adapting the most efficient machines and methods for operations mechanization.

11. OPERATIONS WITH TOPSOIL

One of the specific peculiarities of airport construction is the necessity to create on the airfield conditions for the formation of a sod layer. For this purpose, the entire unpaved part of the airfield should be covered with a topsoil layer of thickness required by agricultural norms.

When cuts are made, a considerable part of the surface is stripped of its topsoil, while at fill sections the topsoil is covered by mineral soil from the cut. For this reason, special measures are taken during earth moving work to preserve and, subsequently, lay out a topsoil layer level with the design surface.

In constructing pavements, conversely, the topsoil should be removed from the entire sub pavement bed, since it does not have sufficient strength. The topsoil can be left only at places where the fills are higher than 0.6 meters, provided that the sod is removed and the topsoil is deeply plowed and broken up. At cut sections (at the air-

field), where mineral soil is uncovered, the topsoil layer is removed before the work starts and is then restored after the mineral soil has been removed. At cut sections, where a sufficient thickness of topsoil remains after the cut is made, it is possible not to perform any additional operations with it.

A topsoil layer is created at fill sections by removing it and then restoring, or by using soil removed from pavement sections. It is also possible to use excess soil removed from the unpaved sections of the runway.

The points and depths of removal and also the thickness of topsoil level subject to restoration on the airfield surface are established in the airport plan and are refined during earth moving operations.

In order to retain [its] agricultural properties, the temporarily removed topsoil should not be mixed with the lower lying soil layers, especially when working with podzolic soils. To prevent extreme drying, simultaneous loosening and breaking up of topsoil should be performed at an area not larger than that covered in a single shift and it should be immediately piled up.

Sections covered by agricultural cultures are not subjected to preliminary loosening and breaking up of topsoil. The topsoil should not contain stones, roots, lumps, pieces of sod and other impurities.

Earth moving operations concerning topsoil include the following:

a) loosening the topsoil layer;

b) removal of roots, stones, etc., which were pulled onto the surface;

c) breaking up the topsoil;

d) removal, windrowing and moving the topsoil to its new location;

e) backfilling (restoration) of the topsoil layer on the airfield surface provided for in the plan;

f) final rolling of topsoil at cut and fill sections.

The composition and order of work involving topsoil are established by the plan for performing the earth moving operations.

At cut sections, the topsoil can be removed simultaneously from the entire area of the contour being worked, or by individual strips, while at fill sections this must be done for the entire area of the contour at the same time. Temporary windrowing of topsoil is most conveniently done outside the limits of the worked section (Fig. 10). However, when dealing with large areas, it may be windrowed on the site proper. In this case, the removal of the topsoil and the subsequent quarrying of the cut are performed in strips, with the topsoil windrowed at intermediate strips (Fig. 11).

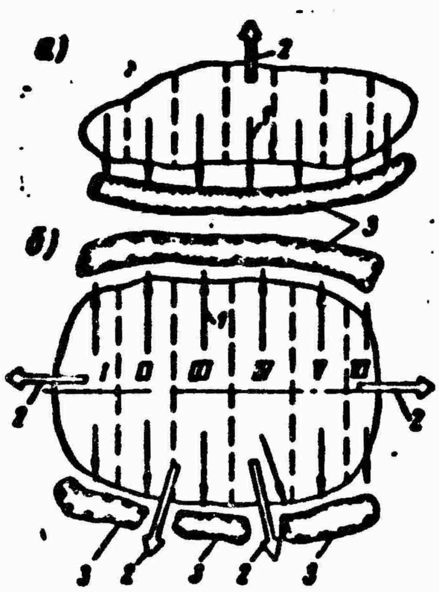


Fig. 10. Scheme for windrowing of topsoil outside the limits of the worked section. a) One-directional; b) two-directional; 1) direction of topsoil displacement; 2) direction of mineral soil displacement; 3) temporary topsoil windrows.

After the earth moving operations are finished and the topsoil layer is restored, the same sequence of work is maintained in working with topsoil at strips which were first used for storing it.

The width of strips from which the topsoil is taken is established, depending on the area and volume of operations and also on the mechanization facilities.

In individual cases, when it is necessary to quarry the entire cut area at the same time, it is permitted to temporary windrow topsoil at the

point where the strips meet.

Topsoil is removed from sections tobbe paved b. individual areas extending over the entire width of the sub pavement bed. Temporary placement of topsoil at the bed shoulders and also at places not provided for in the plan is not permitted.

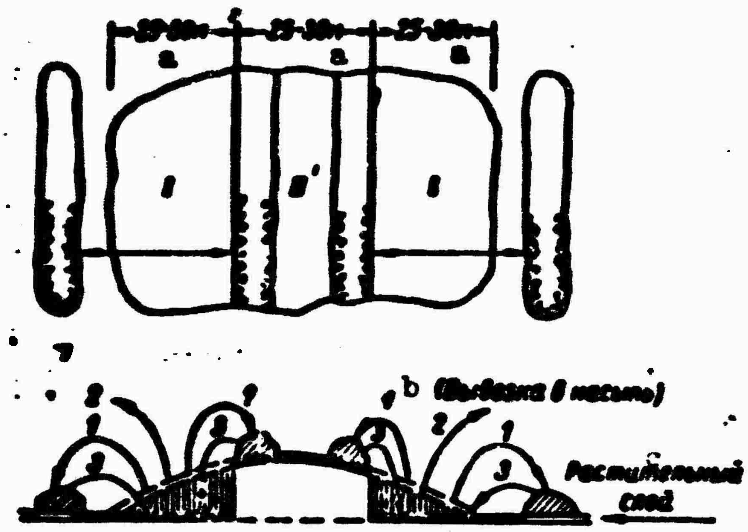


Fig. 11. Scheme for removing and restoring the topsoil layer when making a cut, in alternating strips. a) Meters; b) hauling away to a fill); c) topsoil layer

When the airfield area contains a large number of small cut and fill contours, placed at a comparatively small distance from one another, it is possible to use the mutual exchange method, according to which topsoil of one contour taken from a temporary windrow is immediately moved to another contour, where the work with mineral soil is completed by that time.

The topsoil is loosened and broken up before removal, if this is necessary. This work should be performed at the same time it is windrowed, without allowing excessive drying and breaking up.

Topsoil is loosened by multishare agricultural plows, and at sections from which stumps and brushwood has been cleared this is done by brushwood plows or by five-support cultivators. The plowing patterns

used are strip, loopless and fancy.

The soil is broken up by cultivators, disk and standard harrows pulled by a tractor. The number of passes necessary for loosening is established on the basis of the topsoil density and its moisture content. When a number of passes are made, they are arranged in perpendicular directions if this is possible. The passes of equipment which break up the soil should, in all cases, coincide with the direction of motion of the soil loosening equipment.

The topsoil is removed and replaced by bulldozers, graders, elevating graders, and scrapers. When the hauling distance is moderate (up to 40-60 meters), the bulldozer is the most productive machine, since it completely executes the entire working cycle (removal, windrowing, and replacement of the topsoil).

The basic technical and economic characteristics of bulldozers being used are given in Table 5.

Bulldozers work is traverse cuts, cutting out the topsoil layer of the section and removing it past the limits of the operational area. Depending on the scheme assumed, windrowing can be done on one or two sides (Fig. 10).

The following cutting angles are used: about 45^{o} at difficult virgin soils; and not less than 60^{o} at non-cohesive and previously plowed soils.

The deptch to which the mouldboard is sunk into the soil is most conveniently fixed by skis which are attached to the moulboard. Skis are also used in grading work.

Preliminary loosening and breaking up of topsoil which is worked by a bulldozer is necessary only in the case of difficult virgin soils.

When the layer thickness is not considerable and also when working with podzolic subsoils, it is convenient to remove the topsoil by

a combined grader and bulldozer operation (Fig. 12). In this case, the graders cut off the topsoil and pile it up in longitudinal wind ows placed 2-3 meters from one another. Then, bulldozers are used to further remove the windrows outside the strip being cleared.

Graders work the soil in strips. Tractor-drawn scrapers should be rigidly coupled to the tractor. The coverage angle used at light previously plowed soils is 60-70°, and that used at difficult virgin and sod covered soils is 35-40°. The grader knives are set at 35-50° cutting angles (the smaller values are for difficult soils). The knife should be sunk into the soil uniformly over the entire width of coverage.

Topsoil is removed from windrows to points outside the limits of the section being cleared at both sides of the strip by bulldozer passes across the strip starting from the middle. The bulldozer performs no work at the return trip. Removal can also be effected by bulldozer passes across the entire strip being worked, but this may require several bulldozer passes over the same track, which involves additional unnecessary breaking up and rubbing off of soil particles. To improve the productivity and improve the quality of topsoil removal operations, the cutting edges of the knife should be properly and timely sharpened.

The topsoil layer is restored and leveled out by a bulldozer or grader and it is graded by a motor grader. To increase the productivity in grading, the motor grader should be provided with an extra-length knife. After it has been leveled, the topsoil is finish-rolled by light smooth rollers weighing 3-5 tons.

The topsoil layer is successfully removed from the sub pavement bed by scrapers, which immediately haul away the soil to pre-assigned points. The scrapers move in transverse passes. It is to great advantage if the section width is close to the soil scoop length, but prac-

TABLE 5

Наименование показателей	Показатели по маркам бульдозеров						
	Д-216	Д-159Б	Д-149	Д-157	Д-271	Д-259	Д-275
Длина отвала по ножу, м	2,00	2,28	3,60	2,93	3,03	4,10	3,35
Высота отвала (по хорде), м	0,60	0,80	0,90	1,10	1,10	1,10	1,35
Наибольший подъем отвала над опорной поверхностью гусениц, м	0,60	0,60	0,87	0,90	0,90	1,10	1,40
Наибольшее заглубление отвала ниже опорной поверхности гусениц, м	1,20	0,15	0,20	1,50	1,40	1,0	1,0
Угол резания ножа отвала, град.	60	60	60	45—55	52—62	44—56	55—60
Угол установки отвала в плане, град.	90	90	60—90	90	90	62—90	90
Угол установки отвала в вертикальной плоскости, град.			5—6	—	—	5—6	—
Тип управления	Канатное	Гидравлическое	Канатное				
Габаритные размеры, м:							
длина	3,63	4,30	5,23	5,15	5,10	5,45	6,70
ширина	2,0	2,28	3,56	2,95	3,03	4,10	3,20
высота	2,05	2,30	2,18	2,92	3,0	2,72	2,80
Марка трактора	КД-35	ДТ-54	С-80	С-80	С-80	С-80	ДТ-140
Мощность двигателя, л.с.	37	54	80	80	80	80	140
Расход топлива, кг/час	6	8	12	12	12	12	17
Вес бульдозера, т:							
без трактора и агрегата управления	0,90	0,65	3,0	2,10	1,60	2,50	2,40
с трактором и агрегатом управления	4,7	6,0	14,4	14,2	13,3	14,2	16,8
Вес боковых щитков, т	—	—	—	—	—	—	0,5
Производительность при разработке грунтов и перемещении их на расстояние, $м^3$/час:							
10 м	20—35	40—70	80—140	80—140	80—140	80—140	120—200
30 м	10—15	20—30	40—60	40—60	40—60	40—60	60—90
50 м	—	14—18	28—36	28—36	28—36	28—36	45—55
75 м	—	—	20—25	20—25	20—25	20—25	30—40
100 м	—	—	12—20	12—20	12—20	12—20	20—30

A) Designation of indicators; B) indicators for bulldozer brands; C) D-216; d) D-159B; E) D-149; F) D-157; G) D-271; H) D-259; I) D-275; J) length of blade along the cutting edge, meters; K) blade height (along the chord), meters; L) greatest clearance between the blade and the bearing surface of crawlers, meters; M) greatest depth of penetration of blade below the bearing surface of crawlers, meters; N) cutting angle of the blade knife, degrees; O) angle of setting the blade in the plan, degrees; P) angle of setting the blade in the vertical plane, degrees; Q) type of control; R) cable; S) hydraulic; T) overall dimensions, meters; U) length; V) width; W) height; X) tractor brand; Y) KD-35; Z) DT-54; a) S-80; b) DT-140; c) engine rating, HP; d) fuel consumption, kg/hour; e) bulldozer weight, tons:; f) without the tractor and the control unit; g) with the tractor and control unit; h) weight of side panels, tons; i) productivity in making a cut or fill and hauling away the soil, meters^3/hour; j) meters.

tically, work can be done for any section length and width. The soil is scooped up at a constant depth of cut, which is established depending on the soil type and the required depth to which the topsoil must

be removed.

The topsoil layer from future paved sections can be removed, also, by elevating graders.

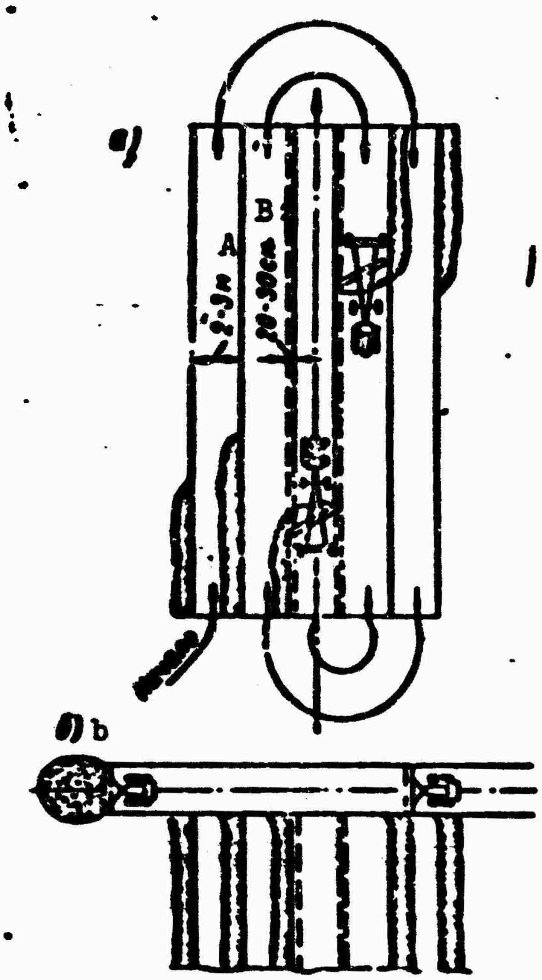


Fig. 12. Scheme of combined grader and bulldozer work in removing the topsoil:; a) Scheme of grader motion; b) scheme of bulldozer motion; A) 2-3 meters; B) 20-30 cm; C) start.

The elevating grader moves along the strip; motions in both directions being working passes, here the turns should be made outside the loading limits. The length of coverage for ensuring normal operation of an elevating grader is established as not less than 150-200 meters, and the width is taken as 15-20 meters. When using elevating graders, the topsoil should not be first loosened.

The productivity of an elevating grader decreases sharply in excessively moist soil and if the soil is considerably littered by small stones. The use of elevating braders under these conditions is not expedient.

The schemes for operating the machines and measures for increasing their productivity are analogous to schemes for excavating mineral soil and are discussed below in more detail.

12. EXCAVATING CUTS WITH SCRAPERS

The scraper unit is a high-productivity earth moving cyclical action machine, which combines the loading [scooping], hauling and unloading of soil, which conveninently distinguishes it from other earth digging machines.

The character of earth moving operations attendant to airport construction, creates especially favorable conditions for the use of scrapers.

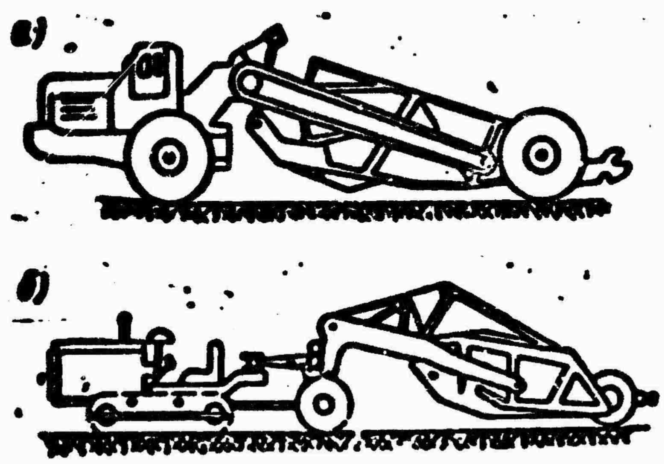


Fig. 13. Scraper types: a) Self-propelled with a single-axis tractor; b) tractor-drawn with a crawler tractor.

Scrapers are used for layer by layer excavation of cuts with moving the soil onto a fill and depositing it in a uniform layer of specified thickness.

In scraper work, a rought grading of the cut and preliminary compacting of soil in fills is also achieved. Scrapers successfully excavate cuts with any volume of earth moving work; here, the greater the volume of the excavated soil, the more efficient is the scraper's work.

For normal scraper operation, the cut length should be slightly greater than the length of the section required for complete loading of the scraper scoop, and the height of the working elevations of the cut should not be less than the design depth of cut of the scraper type being used. Nonconformance to this condition results in lowering the scraper productivity.

In airport construction, use is made of tractor drawn scrapers with a scoop capacity from 1.5 to 15 meters^3 and semi-trailer saddle

type scrapers with single or twin-axle wheeled tractors (Fig. 13). The semi-trailer scrapers are more modern, since due to [their] high speed (up to 0 kilometers/hour), they are distinguished by high productivity, especially in hauling the soil over large distances.

The technical characterization of scrapers is given in Table 6.

In addition to scrapers enumerated in Table 6, the D-373 scraper consisting of paired D-354 scrapers is being adapted (Fig. 14). The D-373 scraper is considerably more productive than the D-354 scraper. Here, the capacity of the DT-54 tractor is more completely utilized. Under difficult conditions (at a very ravinous locality and for a short hauling distance), the D-373 scrapers work with one scoop.

Scrapers can be used for excavating cuts under winter conditions and at night time.

In organizing the work, it should be kept in mind that the productivity of scrapers decreases sharply when excavating excessively moist soils, due to the adherance of soil to the scoop bottom and walls and improper scooping.

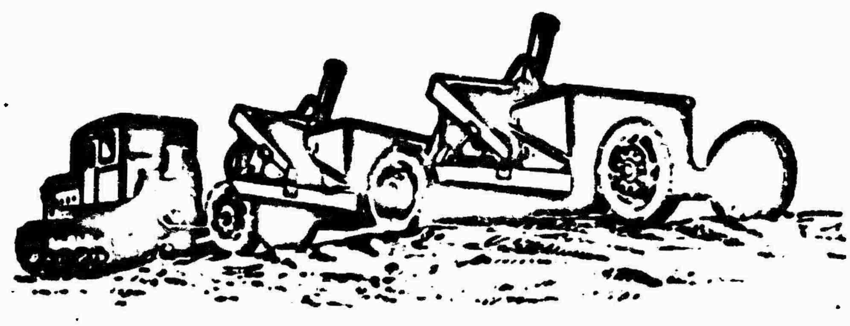


Fig. 14. General view of the D-373 paired scraper.

The operational productivity of scrapers is determined by the formula

$$\Pi_э = \frac{3600 V_к K_н K_в}{T_ц K_р}.$$

where П is the scraper productivity, meters³/hour … tric capacity of the scoop, meters³, K_n is the sc… cient; K_v is the coefficient of working time util… time of one working cycle, sec.; and K_r is the sc… cient.

TABLE 6

1 Наименование показателей	2 Показатели по маркам скреперов								
	Д-217 3	Д-183 (Д-183Б) 3	Д-230 5	Д-354 6	Д-147 7	Д-222 8	Д-222А 9	Д-374 10	Д-21… (Д-213… 1…
Тип скрепера 15	16 Одноосный	17 Двухосный	16 Одноосный	17 Двухосный	17 Двухосный				
Емкость ковша скрепера, м³ 18									
геометрическая 19	1,30	2,25	2,25	2,75	6,0	6,5	6	6	10
с «шапкой» 20	1,70	2,50	2,50	3,00	8,0	8,0		10	12/13…
Ширина резания, мм 21	1100	1860	1860	2160	2592	2592	2592	2592	2830
Наибольшая глубина резания, мм 22	100	150	120	150	300	300	300	320	300
Угол резания ножа, град. 23	30—33	30—35	30—35	35—38	42—47	35	35—30	—	35
24 Наибольший слой отсыпки грунта, мм	—	300	—	—	400	350	350	—	380
Радиус поворота скрепера, м 25	—	3,0	—	—	3,0	—	5,75	—	7,…
Ходовая часть: 27									
число колес 28	2	4	2	4	6	6	6	6	6
размер шин, дюймы 29	10,5—20	10,5—40	10,5—20	10,5—20	12—20	12—20	12—20	12—20	14—…
Давление воздуха в камерах, атм 30	5—5,5	5—5,5	6—6,5	—	5,5—6	5,5—6	—	—	4,5—…
Колея, мм: 31									
32 колес одноосных скреперов	1830	—	2300	—	—	—	—	—	—
33 передних колес двухосных скреперов	—	900	—	900	1640	1640	1250	1250	167…
34 задних колес двухосных скреперов	—	1400	—	1630	1780	1780	1780	1780	18…
Дорожный просвет под ножами ковша скрепера с транспортном положении, мм 35	220	270	220	230	600	350	550	500	55…
Наименьшая ширина пути для поворота на обратный ход, мм 36	7000	9000	8000	9000	13 000	12 300		-	1500…
Управление 37	Канатное 38	Гидравлическое 39			38 Канатное				
Габаритные размеры, мм: 40									
длина 41	3800	5450	4350	5600	9 140	8 800	8 400	8 400	98…
ширина 42	2200	2850	2990	2430	3 150	2 990	3 050	2 990	32…
Высота в транспортном положении, мм 43	1625	2400	1520	2400	3 500	3000	3 090	3 090	31…
Длина в сцепе с трактором и тягачом, мм 44	6700	8700	7600	8850	13 140	12 800	12 400	12 800	1380…
Тип трактора или тягача 45	КД-35 46	ДТ-54 47	ДТ-54 47	ДТ-54 47	С-80 48	С-100 49	С-100 49	С-100 49	С-…
54 Мощность тягача или трактора, л.с.	37	54	54	54	80	100	100	100	1…
55 Вес порожнего скрепера, кг	1350	2330	1850	2320	6 600	6 000	6 360	6 600	91…
56 Вес в сцепе с трактором, кг	3800	8000	7500	7870	18 750	18 750	18 710	18 750	206…
57 Способ разгрузки	58 Опрокидывание ковша вперед				Принудительное 59	Полупринудительное 60			

1) Designation of indicators; 2) indicators by … D-217; 4) D-183 (D-183B); 5) D-230; 6) D-354; 7) … D-222A; 10) D-374; 11) D-213 (D-213A); 12) D-35… 14) D-189; 15) type of scraper; 16) single axle … capacity of scraper scoop, meters³; 19) geometr…

where П is the scraper productivity, meters^3/hour; V_k is the geometric capacity of the scoop, meters^3, K_n is the scoop filling coefficient; K_v is the coefficient of working time utilization; T_{ts} is the time of one working cycle, sec.; and K_r is the soil loosening coefficient.

TABLE 6

1 ...телей	2 Показатели по маркам скреперов											
	Д-217 3	Д-183 (Д-183Б) 4	Д-230 5	Д-354 6	Д-147 7	Д-222 8	Д-222А 9	Д-374 10	Д-213 (Д-213А) 11	Д-357 12	Д-188, Д-188А 13	Д-189 14
15	16 Одноосный	17 Двухосный	16 Одноосный	17 Двухосный	17 Двухосный					16 Одноосный	17 Двухосный	16 Одноосный
18 ... $м^3$ 19	1,50	2,25	2,25	2,75	6,0	6,5	6	6	10	9	15	15
20	1,70	2,50	2,50	3,00	8,0	8,0		10	12(13)	11	18	17
21	1100	1800	1860	2100	2592	2592	2592	2592	2830	2780	3121	3100
...ания, мм 22	100	150	120	150	300	300	300	320	300	300	300	300
23	30—35	30—35	30—35	35—38	42—47	35	35—30	—	35	—	35	35
24 ...и грунта, мм	—	300	—	—	400	350	350	—	300	До 450	400	До 400
...ра, м 25	—	3,0	—	—	8,0	—	5,75	—	7,25	26 —	8,02	26 —
28	2	4	2	4	6	6	6	6	6	2	6	2
29	10,5—20	10,5—40	10,5—20	10,5—20	12—20	12—20	12—20	12—20	14—20	21—28	18—28	18—28
...мерах, атм 30	5—5,5	5—5,5	6—6,5	—	5,5—6	5,5—6	—	—	4,5—5	—	4—4,5	—
...скреперов	1800	—	2500	—	—	—	—	—	—	2200	—	1850
...ухосных скре...	—	900	—	900	1640	1640	1250	1250	1670	—	2200	-
...хосных скре...	—	1400	—	1650	1780	1780	1780	1780	1880	-	2000	—
...ножами поп...ортном поло...	220	270	220	230	600	550	550	500	550	570	550	550
...ти для пово...а, мм 36	7000	9000	8000	9000	13000	12500	.	-	15000	—	19000	—
37	38 Канатное	39 Гидравлическое			38 Канатное				39	Гидравлическое	38 Канатное	
...м: 40	3800	5450	4350	5600	9140	8800	8400	8400	9800	5607	10925	21800
	2200	2850	2990	2430	3150	2930	3050	2930	3230	3230	3470	3500
...положении, 43	1625	2400	1520	2400	3500	3000	3090	3070	3150	3200	3100	3500
...ором и тяга... 44	6700	8700	7600	8850	13140	12800	12400	12800	13800	10270	16225	13900
...а 45	КД-35 46	ДТ-54 47	ДТ-54 47	ДТ-54 47	С-80 48	С-100 49	С-100 49	С-100 49	С-140 50	МАЗ-529В 51	С-140 и толкач	МАЗ-525Д 53
...рактора, л.с.	37	54	54	54	80	100	100	100	140	165	140	300
...а, кг	1350	2330	1850	2320	6600	6800	6360	6600	9100	8350	15750	14000
...ом, кг	3800	8000	7500	7970	18750	18750	18710	18750	20670	18000	30850	35000
	58 Опрокидывание ковша вперед				59 Принудительное	60 Полупринудительное				59 Принудительное	60 Полупринудительное	

1) Designation of indicators; 2) indicators by scraper brands; 3) D-217; 4) D-183 (D-183B); 5) D-230; 6) D-354; 7) D-147; 8) D-222; 9) D-222A; 10) D-374; 11) D-213 (D-213A); 12) D-357; 13) D-188, D-188A; 14) D-189; 15) type of scraper; 16) single axle; 17) twin axle; 18) capacity of scraper scoop, meters^3; 19) geometric; 20) heaped; 21)

21) width of cut, mm; 22) greatest depth of cut, mm; 23) cutting angle of knife, degrees; 24) greatest soil fill layer, mm; 25) scraper turning radius, meters; 26) up to; 27) the wheel system:; 28) number of wheels; 29) tire dimension, inches; 30) air pressure in chambers, atm; 31) gauge, mm:; 23) of single axle scraper wheels; 33) of front wheels of twin axle scrapers; 34) of rear wheels of twin axle scrapers; 35) road clearance under scraper scoop knives in the transportation position, mm; 36) smallest path for reversing direction of motion, mm; 37) control; 38) cable; 39) hydraulic; 40) overall dimensions, mm:; 41) length; 42) width; 43) height in moving position; 44) length when coupled to a tractor or tow car; 45) tow car of tractor type; 46) KD-35; 47) DT-54; 48) S-80; 49) S-100; 50) S-140; 51) MAZ-529V; 52) S-140 and pusher; 53) MAZ-525D; 54) tow car or tractor rating; HP; 55) weight of empty scraper, kg; 56) weight when coupled to tractor, kg; 57) method of unloading; 58) turning over the scoop in forward direction; 59) positive; 60) semipositive.

The duration of one working cycle will be equal to

$$T_c = \left(\frac{l_n}{v_n} + \frac{l_{gr}}{v_{gr}} + \frac{l_r}{v_r} + \frac{l_{kh}}{v_{kh}} + t_{pr}\right).$$

where l_n/v_n is the time for filling the scoop, secs.; l_{gr}/v_{gr} is the soil hauling time, secs.; l_r/v_r is the scraper unloading time, secs.; l_{kh}/v_{kh} is the returning time of the empty scraper, secs.; t_{pr} are other time expenditures (turns, shifting of gears, etc.), secs.; l_n, l_{gr}, l_r, l_{kh}, v_n, v_{gr}, v_r and v_{kh}, respectively are distances and rates of loading, hauling, unloading and the return trip of the scraper.

The duration of the working cycle and the coefficient of scraper scoop filling are the basic factors which substantially influence the scraper productivity.

Optimal Conditions for Loading Soil into the Scraper Scoop

An attempt should be made at the soil loading section to achieve maximum filling of the scoop at the shortest distance.

The length of path required for filling the scraper depends on the scoop volume and on the degree to which it is filled, on the width and depth of cut and on the soil loosening coefficient.

The distance of scraper scoop filling is determined by the formula

$$l_n = \frac{V_c K_n}{b h K_p}\ m,$$

where V_k is the geometric capacity of the scraper scoop, meters^3; K_n is the filling coefficient; K_r is the loosening coefficient; B is the width of cut, meters and h is the thickness of the layer being cut, meters.

Before the earth moving operations start, the loosening coefficients should be determined experimentally by the construction laboratory for each section.

The average values of soil loading paths for scrapers are as follows:

D-183, D-230 (2.25-2.50 meters^3)	12-14 meters
D-288 (6-8 meters^3)	18-22 "
D-213 (10-12 meters^3)	26-28 "
D-188 (15-18 meters^3)	35-38 "

When loading cohesive soils into the scraper scoop, the soil layer at the beginning of cut moves along the bottom, then, having reached the rear wall is broken up and continues to move into the scoop over soil which is already there. Further filling of the scoop takes place by successive deposits of soil layers.

After the lower part of the scoop is filled, the cut soil layer can get into the scoop only by overcoming the thickness of soil already in the scoop. This character of filling shows that the loading regime should not be constant. For this reason, cohesive soils should be cut by the wedge method (Fig. 15).

At the beginning, the soil is loaded at an optimal depth of cut, with maximal utilization of the tractor capacity. Subsequently, due to increasing pulling resistance, when the insufficient capacity of the engine is felt, the depth of cut is gradually decreased. Thus, the loading section passed by a scraper takes on a stepped or wedge shaped form.

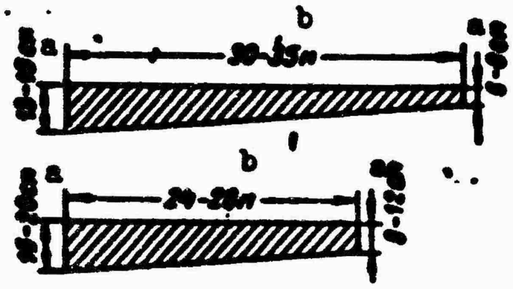


Fig. 15. Wedge schemes of cutting in excavating sandy loam and argillaceous sand soils using D-222 scrapers. a) cm; b) meters.

When a scraper works in loose soil, no soil shavings are obtained, a roll of soil is formed ahead of the knife. For this reason, at loose soils (sand, sandy loam), which fill the scoop poorly, use should be made of the wave shaped cutting scheme (Fig. 16), in which the scoop is first lowered to maximum depth and then, when the engine starts to work unevenly, the apron is lowered on the drag prism, and the scoop is raised.

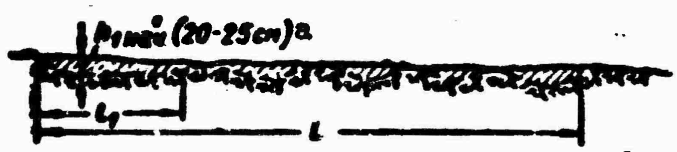


Fig. 16. Wavy cutting scheme.
a) $h_{1\ nach.}$ (20-25 cm).

The scoop is raised and lowered several times (4-5 and more). Here, due to the upward motion of the scoop, the soil is several times moved toward the rear wall and, on multiple "bites", the scoop is filled by 10-15% more.

The use of the wave shaped scheme interferes with intensive increase of the drag prism and, consequently, has a beneficial effect on the scoop filling.

When loading soil by the wavy scheme, the tractor operator should pay special attention to the winch and not allow it to overheat.

Soil is cut to variable depth in rough cuts, when the height of working elevations exceeds the maximum penetration of the scraper scoop. The last scraper passes also effect rough grading of the cut surface, for which reason, despite the lowering of the filling coefficient, it becomes necessary to use a constant cutting depth.

The effectiveness of filling the scoops of D-147 and D-222 scra-

pers with soil, depends on the apron position during cutting. In the beginning of loading, when the soil flows freely from the cutting edge to the back wall and is spread on the scoop bottom, the apron should be lifted by 60-70 cm, so as not to interfere with the soil entering the scoop.

Then, when the soil beging to accumulate at the forward part of the scoop, the clearance between the cutting edge and the apron is decreased by 20-25 cm at noncohesive soils and by 40 cm at cohesive soils. At the end of the filling operation, when the soil is supplied to the scoop at high pressure, the apron should again be raised by 15-20 cm (Fig. 17).

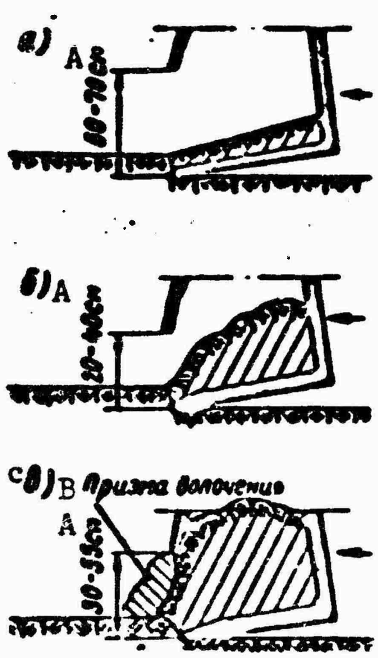


Fig. 17. Position of aprons of D-222 (D-147) scrapers during the f filling of scoop. a) first period; b) second period; c) third period; A) cm; B) drag prism.

It is expedient to cut the soil according to an alternating comb-like scheme (Fig. 18). The substance of this method consists in the fact that the soil is cut from the edge of the cut by individual strips, so that a strip of uncut soil, equal approximately to half the width of the scraper scoop, remains between them. The cutting row following the first starts approximately from the middle of the path needed for filling the scoop when cutting the first row. At the end of filling operation, when the greatest pulling effort by the tractor is required, a narrower strip is cut and the side walls of the scoop are not required to perform cutting work, which creates conditions for more complete and rapid filling of the scoop. The scoop filling coefficient reaches 1.1, and the filling time is decreased by approximately

a factor of 1.5 in comparison with straight cutting

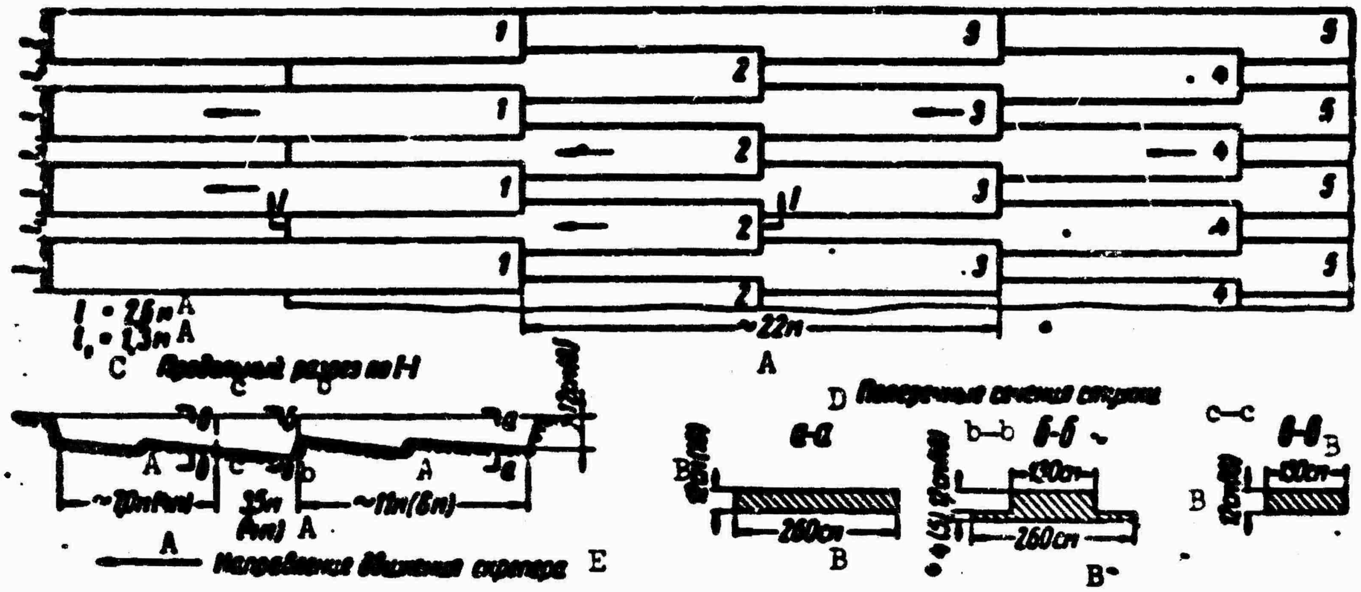


Fig. 18. Alternating comb-shaped scheme for soil cutting by scrapers. 1, 2, 3, etc., is the sequence of cuts. Dimensions in parentheses are for low-cohesion soil. A) Meters; B) cm; C) longitudinal section I-I; D) cross sections of chips; E) direction of scraper motion.

To better fill the scraper scoop, especially at cohesive soils, it is recommended to install special teeth or stepped cutting edges (Fig. 19).

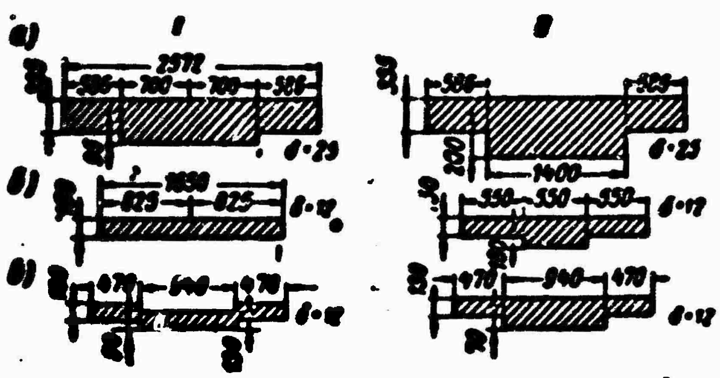


Fig. 19. Used and recommended types of cutting edges for scrapers of the following brands: a) D-222; b) D-183B; c) D-354; I) old design; II) recommended design

It is recommended that cutting edges be reversed, or replaced, on the average after 300-400 hours of work. Irrespective of the cutting method, the soil should be loaded with maximally possible layer thickness. The recommended depth of cut is given in Table 7.

TABLE 7

Емкость ковша прицепного скрепера, м³ A	B Мощность, л.с.		C Рекомендуемая глубина зарезания, см		
	D трактора-тягача	E трактора-толкача	F песка	G суглинка	H глины
6	80–93	—	20	12	9
10	80–93	80–93	30	18	14
15	140	140	30	21	16

A) Scoop capacity of the drawn scraper; B) rating, HP, of; C) recommended cutting depth, cm; D) pulling tractor; E) pusher tractor; F) sand; G) loam; H) clay.

The total tractor pull is used only at the end of scoop filling. The pull effort in loading of soil can be temporarily increased by using a pusher tractor, whose rating should correspond to that of the pulling tractor. The scraper and pusher should always move along the same line with the same speed.

The use of a pusher is the more advantageous, the longer the working cycle and the larger the scraper for the same tractor pull (furthermore, a pusher coupled to a ripper can be used for loosening the soil). The use of a pusher is most effective for several scrapers. One pusher located in the cut will, in turn, serve several scrapers, the number of which can be determined by the formula

$$N_{skr} = \frac{T_{ts}}{t_n + t_p},$$

where N_{skr} is the number of scrapers served by a single pusher; T_{ts} is the duration of the scraper working cycle; t_n is the scoop filling time; t_p is the time spent by the pusher in moving from one scraper being served to another.

In serving several scrapers by one pusher at extensive cuts, it is recommended to use the chain loading scheme consisting in the fact that the pusher is positioned on the soil loading line and, in sequence as it moves, it assists the scrapers in cutting into the soil

(Fig. 20). At the beginning, the pusher assists the first scraper in loading soil, then in sequence, it assists the second and the third. This method considerably decreases the time spent in maneuvering the pusher. If the cut is situated between two fills, then the method of pusher-scraper operation shown in Fig. 21 can be used.

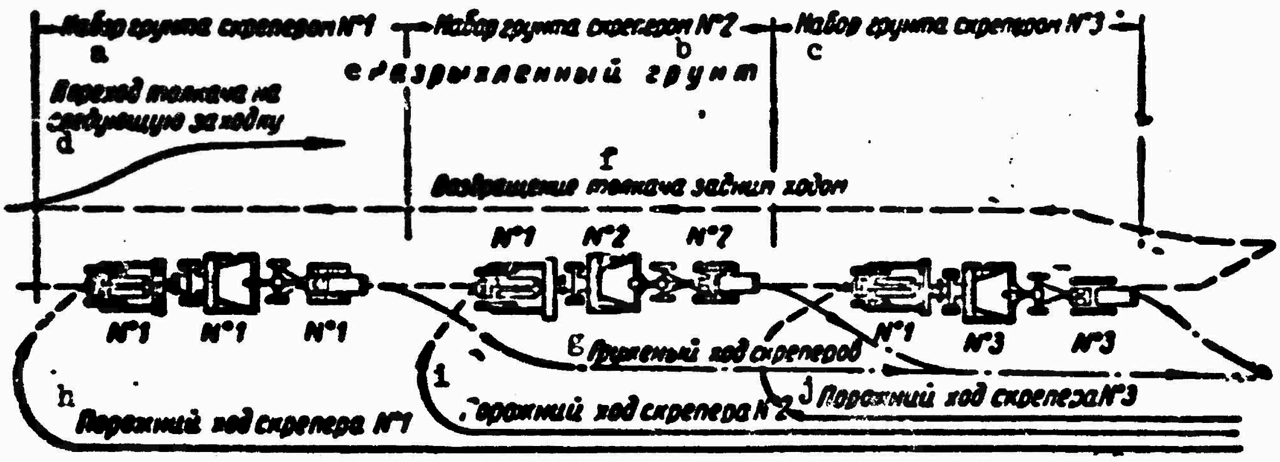


Fig. 20. Work of scraper with a pusher in cutting of soil. a) Loading soil by scraper No.1; b) soil loading by scraper No.2; c) soil loading by scraper No.3; d) the pusher moves to new position; e) loosened soil; f) pusher returns in reverse; g) movement of loaded scrapers; h) movement of empty scraper No.1; i) movement of empty scraper No.2; j) movement of empty scraper No.3.

When working in hard soils, which excavate with difficulty, preliminary loosening should be performed, which is usually done by the D-162A heavy type ripper. To improve the scoop loading, the soil should not be excessively pulverized, for which reason it is recommended to remove two teeth from the ripper.

Excessive pulverization of the soil results in lowering the pulling effort of the tractor and in increasing the resistance to the scraper motion.

The soil is loosened by layers. It is not permitted to produce a large stockpile of loosened soil, since it dries out in hot weather, the lumps harden and further excavation and compacting in fills of this soil is made more complicated, and in the excessively moist state certain loosened soils melt and then do not dry for long periods.

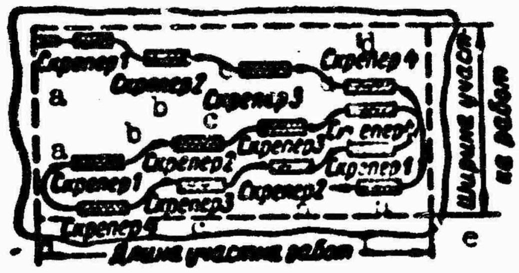


Fig. 21. Scheme of pusher operation when a cut is situated between two fills. a) Scraper 1; b) scraper 2; c) scraper 3; d) scraper 4; e) width of work section; f) length of work section.

Innovating scraper operators, when working in hard soils, use volume loosening teeth mounted on the scraper cutting edge, which increases the productivity by 30-40%.

Substantial influence on scraper productivity is exerted by the moisture content of the excavated soil. The traction between crawlers and the ground, decreases sharply when working in raw and sticky soil, and the attendant skidding decreases the filling of the scraper scoop. The work of scrapers under these conditions is very difficult and practically inexpedient. However, increasing the soil moisture content to specified limits, conversely, improves the scraper's working conditions, since it results in lowering the cutting force and increases the cohesion of sandy soil.

Better scoop filling is achieved in working with loamy soil with an approximately 15% moisture content, and in sandy and sandy loam soils with an 8-9% moisture content. Extremely dry soil should be artificially wetted.

In excavating cuts, proper use should be made of the local topography. As far as possible, the soil should be loaded when the scraper unit moves downhill along the slope.

Work along a slope ensures the smallest expenditure of capacity with the highest value of filling coefficient. Thus, the required pulling effort for a tractor coupled with a D-222 scraper decreases by 7-12% in comparison with loading on a level section. The obtained tractor force reserve makes it possible to increase the shaving thickness and, consequently, also the coefficient of scraper scoop filling

by a factor of 1.2-1.5.

Preliminary grading of the surface of the cut should be achieved on final scraper passes (Fig. 22).

Fig. 22. Scheme of scraper work on grading of the airfield surface: a) Scheme of scraper motion; b) position of the scraper's working elements with semi-positive unloading.

The scraper scoop cutting edge cuts off small mounds and fills small depressions with the soil thus cut off, thus grading the surface. Highly skilled scraper operators obtain grading precision within the limits of ± 6-8 cm. In grading, care should be taken that the pressure in the scraper's tires should be the same.

<u>Hauling the Soil from Cuts into Fills</u>

The soil hauling operations by scrapers consist of the hauling proper of the soil to the fill and returning the scraper to the cut to the soil loading point. The time needed for these operations is determined by the formula

$$t_{tr} = \frac{l_{gr}}{v_{gr}} + \frac{l_{por}}{v_{por}} + t_z$$

where t_{tr} is the time of hauling operations; l_{gr}/v_{gr} is the soil hauling time; l_{por}/v_{por} is the empty trip time, t_z is time spent in turning and changing gears.

Even when the hauling distance is not considerable (100-250 meters), the time used up for hauling operations comprises 70% of the total productivity of the cycle and has a substantial effect on the scraper productivity.

An attempt should be made that the loaded scraper should move, as far as possible, downhill, using for this purpose the topography of the locality, or by appropriately organizing the work of the scrapers.

Soil hauling roads must be built and maintained in good condition for the movement of scrapers. This can be done by the scrapers, or by a specially assigned bulldozer which patrols the construction site. The expenditures incurred in maintaining soil-hauling roads, pay for themselves fully by increasing the scraper's productivity.

In excavating cuts with design elevations of more than 1.5 meters, the construction of special ramps is required.

Efficient utilization of scrapers requires a thoroughly thought out scheme of their movement, which is chosen taking into account the following basic requirements:

a) the scraper should move from the cut to the fill along the shortest route without turning around and using favorable slopes;

b) the length of the quarry should be such that it would ensure complete loading of the scraper scoop;

c) the length of the unloading path should be sufficient for complete and convenient unloading of the scoop.

The following schemes of scraper travel are most frequently used in airport construction:

1) along an ellipse;

2) along a two-sided ellipse;

3) zigzag;

4) along a two sided loop (figure eight).

Moving along an ellipse, the scraper, upon loading soil in the cut moves to the unloading site of the fill, unloads and returns to the cut, moving along a closed elliptical curve (Fig. 23a). Here, one working cycle of the scraper contains two turns. To prevent nonuniform

wearing of the traction system, it is expedient to periodically change the direction of scraper motion. The scraper scoop is filled in the cut and unloaded in the fill along rectilinear paths.

Scraper travel along an ellipse is used in the case when the work site consists of individual cuts and fills far removed from one another (300-500 meters), with a local balance of earth masses.

When a cut is situated between fills, use is made of the <u>two-sided ellipse</u> scheme of motion (Fig. 23b), moving along which the scraper is twice loaded and unloaded in a single cycle. Working along this scheme, the scraper makes two 180° turns when performing two unloading operations. The two sided elliptical scheme is most effective when hauling soil over distances not greater than 200-250 meters and when the operations are performed in sections, or small section, with a common balance of earth masses within the limits of several cuts and fills, situated at comparatively moderate distances from one another.

The <u>zigzag</u> scheme of scraper operation is efficient when cuts and fills of considerable length and small width are situated close to one another.

The scrapers move along a zigzag-shaped line along the fill, alternately moving into the cut for loading soil and into the fill for unloading. At the end of section, the scrapers make a 180° turn and return, repeating alternate loading and unloading of soil.

The zigzag scheme of scraper movement gives considerable saving of time in making turns. The disadvantage of this system is the large number of ascents and descents.

The scraper movement schemes discussed above are only basic and will change depending on the specific working condition. Thus, for example, when the cuts are situated parallel (relative to) fills and when the soil-hauling distance is greater than 200 meters, it is ex-

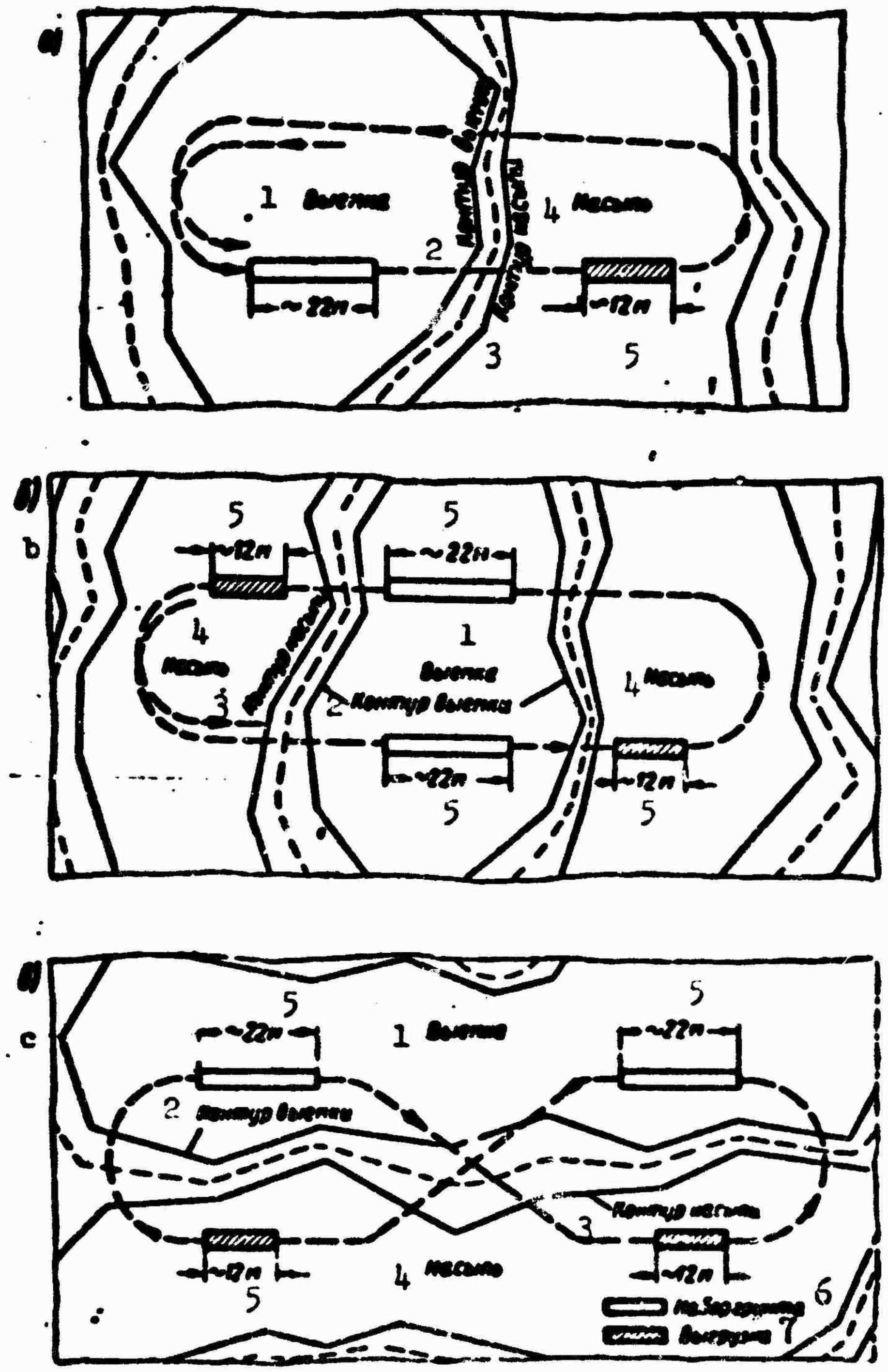


Fig. 23. Scheme of scraper movements in excavating cuts: a) Elliptic; b) two-sided ellipse; c) along a two-sided loop; 1) cut; 2) contour of cut; 3) contour of fill; 4) fill; 5) meters; 6) soil loading; 7) unloading.

pedient for the scraper to move along a double loop scheme (Fig. 23c). When moving along this scheme, the scraper makes 180° turns at the ends of the section and 30-40° turns in the middle part.

<u>Unloading the Soil</u>

When unloading the soil into a fill, special attention should be

paid to quality performance of this operation. The time of soil unloading by scrapers is not considerable and does not, as a rule, exceed 2-3% of the total duration of the working cycle.

The soil supplied by scrapers directly to the filling point should be unloaded in strips along the fill axis. The scoop is unloaded with the tractor in second gear moving along a straight line, which ensures normal operation of the tractor and proper grading of the soil being unloaded. For soil unloading, the scoop is lowered so that a clearance can be obtained between the cutting edge and the fill, equal to the thickness of the unloaded layer.

When unloading loose and free flowing soils, the scoop apron is raised by 40-50 cm, and when unloaded heavy sticky and cohesive soil it is first raised to full height and then, as the soil is pushed out, it is alternately raised and lowered, thus loosening the soil.

The unloading of scrapers in raw soils, as is the case with loading, is difficult. For this reason, the unloading in these soils should be performed gradually, in several steps, by alternately moving the tailgate or the bottom forward and then backward. The unloading should not be performed att at one time, since this results in overstraining and increased wear of the cable and winch. The scoop must be systematically cleaned of the soil which sticks to it.

Sand is expediently unloaded by thin layers, which ensures its better compacting and lowers the resistance to the motion of scraper and tractor.

The soil is filled in layers of specified thickness; the succeeding layer is filled alongside the preceding one to obtain an even fill surface. It has been established that multiple passes of a tractor and scraper along the same path, effect preliminary compacting of soil which decreases the need in subsequent compacting. For this reason, in

order to provide for preliminary compacting of the fill, the unloading of scrapers is started at the forward edge of the section so that each succeeding soil load is unloaded at the end of the preceding filling.

The D-147, D-222, D-213 and D-118 scrapers are unloaded in forward motion, and D-183, D-230 and D-217 scrapers are unloaded by overturning the scoop in the forward direction.

After unloading, the scoop is placed in the traveling position. The scraper is transported in high tractor gear.

Organizing Scraper Operations

Scraper operations, as a part of earth moving operations, are performed on the basis of the operations organization plan.

The excavating work should begin at the highest point of the cut and the soil should be filled at the lowest point of the fill.

Preparatory work, which includes: clearing the site of roots, stones, stumps; temporary drainage of the site; construction of soil hauling roads from the cut to the fill; loosening the soil (if this is necessary), should be finished prior to the commencement of scraper operations.

Having performed the necessary preparatory work and having removed the topsoil layer, an immediate start is made of scraper operations.

The scraper operators, after familiarizing themselves with the recommended scheme, should be familiarized at the site with working conditions (topography, soils, hauling distance, etc).

The routes of soil hauling roads are laid out so as to minimize the number of turns made by the loaded scraper.

For grading work, the bottom and apron of scraper is raised and the cutting edge is lowered to the required depth.

The type of scraper is chosen in accordance with average soil hauling distances, the character and amount of earth moving work.

The economically expedient soil hauling distance for the D-217 scraper (1.5 $meters^3$) is up to 100-150 meters, for the D-183 scraper (2.25 $meters^3$) it is up to 150-200 meters, for the D-149 and D-222 scrapers (6.0 $meters^3$) it is up to 400 meters, for the D-213 scraper (10.0 $meters^3$) it is up to 600 meters, and for the D-188 scraper (15.0 $meters^3$) it is up to 800 meters. For larger hauling distances, it is more expedient to use self-powered scrapers.

Increasing the hauling speed is the most effective measure for increasing the productivity of scrapers.

At cuts with large volumes of earth moving work, it is always expedient to use high capacity scrapers, even when the soil hauling distance is small.

The basic conditions for high scraper productivity are:

compiling of a well thought-out scheme for the movement of scraper units and strict adherance to them;

timely performance of all preparatory work;

construction of earth hauling roads;

proper use of the tractor capacity;

use of pusher tractors in loading soil onto the scraper scoop or preliminary loosening of the soil;

ensuring maximum filling of scoop over the shortest distance;

proper use of tractor gear [positions] in filling the scoop and moving the scraper;

increasing the time utilization coefficient, which is achieved by careful maintenance and quality repair of the scraper and tractor;

proper choice of the scraper type depending on the character of operations and the average soil hauling distance;

systematic sharpening of the cutting edge and installing teeth on the cutter in hard soils.

Cuts can be excavated by scrapers even at night, for which the lightning system and electrical equipment should be in good working order. Cut and fill sites where a large amount of work is performed should be additionally lighted. Use can be made for this purpose of type P30-45 projectors, mounted on wooden or metallic towers up to 6 meters high.

The scrapers should work at least in two shifts. The norm per each cubic meter of scoop capacity is 5.5-6.0 thousand meters^3 per year.

13. BULLDOZING OF CUTS

The use of bulldozers is efficient when excavating comparatively narrow cuts adjacent to fills, if the soil hauling distance does not exceed 40-60 meters, or up to 100 if a favorable downhill slope is available. When soil has to be hauled over larger distances, the bulldozer productivity decreases sharply and its operation ceases to be economical.

The bulldozer, as the scraper, performs by itself almost the entire cycle of earth moving operations, namely: cutting the soil and moving it to the fill, unloading and rough grading.

Cuts are bulldozed by transverse passes. The soil is cut off in individual strips, the thickness of which depends on the soil, its density and the tractor capacity. The sequence of bulldozer passes should be such that the cutting and hauling of soil should proceed downhill, and the loaded and empty trips should be shortest with the smallest possible number of turns.

In airport construction, use is made of bulldozers mounted on crawler tractors KD-35, DT-54, S-80 and DT-140. The technical and ope-

rational characteristics of bulldozers were given in Table 5. A bulldozer can [also] be mounted on a twin-axle wheeled tractor.

The bulldozer productivity in excavating and hauling of soil is determined by the formula

$$\Pi = \frac{3600 q K_{vr}}{T} \text{ m}^3\text{/hour}$$

where q is the soil volume in solid state moved by the bulldozer, meters^3; T is the duration of cycle, secs.; K_{vr} is the bulldozer time utilization coefficient, equal to 0.85-0.90.

The volume of solid soil moved by a bulldozer can be approximately determined by the formula

$$q = \frac{lH\frac{H}{\operatorname{tg}\varphi}\mu K_r}{2} = \frac{lH^2\mu K_r}{2\operatorname{tg}\varphi} \text{ m}^3,$$

where l is the blade length, meters; H is the blade height, meters; K_r is a coefficient accounting for the loosening of the soil; Φ is the angle of the natural slope; and μ is the loss coefficient, depending on the soil hauling distance; A.I. Anokhin recommends that it be calculated by the formula

$$\mu = 0.005L,$$

where L is the soil hauling distance, meters.

The duration of cycle, secs.

$$T = \frac{l_r}{v_1} + \frac{l_{per}}{v_2} + t_p + \frac{l_{per}}{v_3} + t_0,$$

where l_r is the cutting path, meters; l_{per} is the hauling distance, meters; v_1, v_2 and v_3, respectively, are the tractor speed in the cutting process, in soil hauling and on the return trip, meters/sec; and t_0 is the time taken up by turning the tractor about, shifting gears, lowering the blade and other auxiliary operations, $t_0 \approx 20$ secs.

The bulldozer productivity can be increased by increasing the volume of soil moved by the blade, decreasing the time per cycle, and

also be increasing the time during which the bulldozer works in a shift.

The bulldozer work consists in the following operations: cutting and loading of soil; moving soil to the fill; unloading the soil at the fill, returning the bulldozer.

Cutting and Loading the Soil

In the cut, a soil shaving is cut and a soil mass is accumulated ahead of the blade. The length of the soil loading section l_1, for a bulldozer is determined by the formula

$$l_1 = \frac{q}{bhK_r} + l_{dor} \text{ m},$$

where $\underline{q}$ is the volume of soil, moved by the bulldozer blade, meters^3; $\underline{b}$ is the width of blade coverage, meters; $\underline{h}$ is the cutting depth, meters; K_r is the soil loosening coefficient and l_{dor} is the length of the soil cutting section.

To accelerate the loading and to increase the volume of soil ahead of the blade, it is necessary to sprinkle dry sandy or excessively dry soils. For this purpose, it is also important to use efficient soil cutting schemes and to use bulldozers with flanges welded to the blade. The cutting angles are assumed depending on the kind of work and the soil type; when working in hard soils, a 45-50° cutting angle is used, in light soils the blade is set at 80-90°.

When working down a 10-15° slope along the line of motion, the soil is cut in a uniform thick layer. When loading soil on level sections, use ia made of a comb-like cutting system, in which the blade at the beginning is lowered to the greatest possible depth, and then when the engine becomes overloaded, it is raised by approximately 80%. After the engine has been restored to the normal rpm, the blade is again lowered to the greatest possible depth. This is repeated several

times, the knife being lowered to a smaller depth each time, depending on the engine overloading. Approximate cutting schemes under different soil conditions for the D-271 bulldozer are given in Fig. 24.

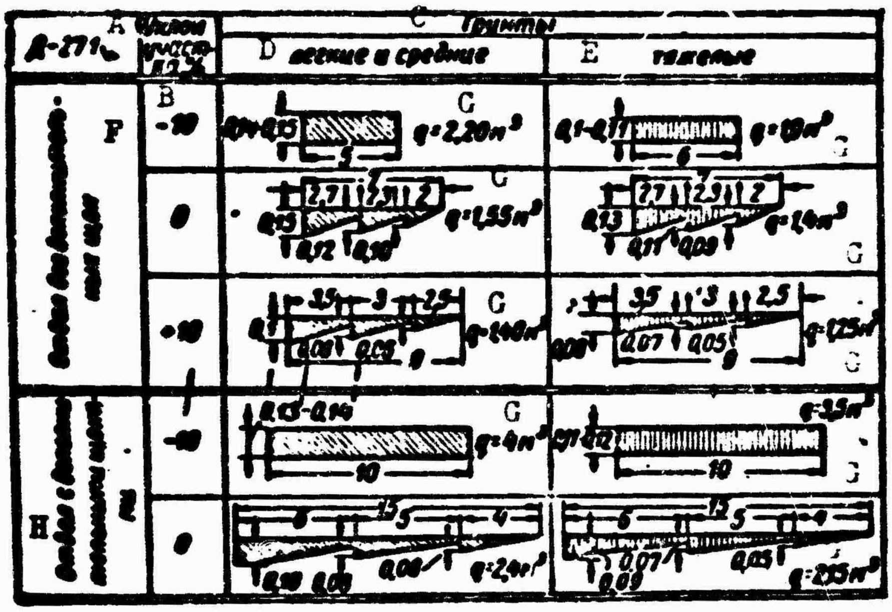


Fig. 24. Cutting scheme in different soils at different slopes (the D-271 bulldozer). A) D-271; B) slope of section, %; C) soils; D) light and medium; E) hard; F) blade without flanges; H) blade with flanges; G) meters^3.

When excavating soils of catergories I and II, it is advantageous to use a wedge-shaped soil cutting scheme (Fig. 25). If the bulldozer blade is equipped with flanges, then the wedge scheme is not efficient, since it ensures a smaller soil load than the comb-like scheme.

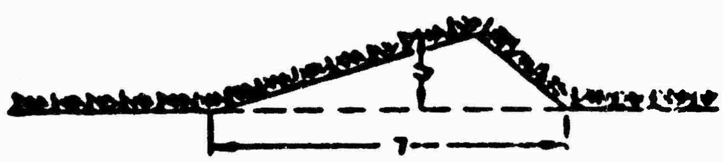


Fig. 25. Wedge scheme of soil cutting.

The soil loading speed is greatly affected by the state of the cutting edge of the knife (knives are made with two sharpened edges). Knives are replaced every 1000-1200 hours of work in light soils and every 400-600 hours of work in hard soils.

Bulldozers are most productive in excavating noncohesive soils (loams, not loose sand, sand and gravel soils, etc.). The soil loading route in hard dense or dried out soils is increased (by a factor of 1.5), for which reason the soil should be first loosened under these conditions. This is done by placing steel teeth on the blade's cutter. When the tractor moves forward, the teeth are retracted and do not interfere with the work. When the tractor moves in reverse, the teeth are lowered into the soil and loosen it (Fig. 26).

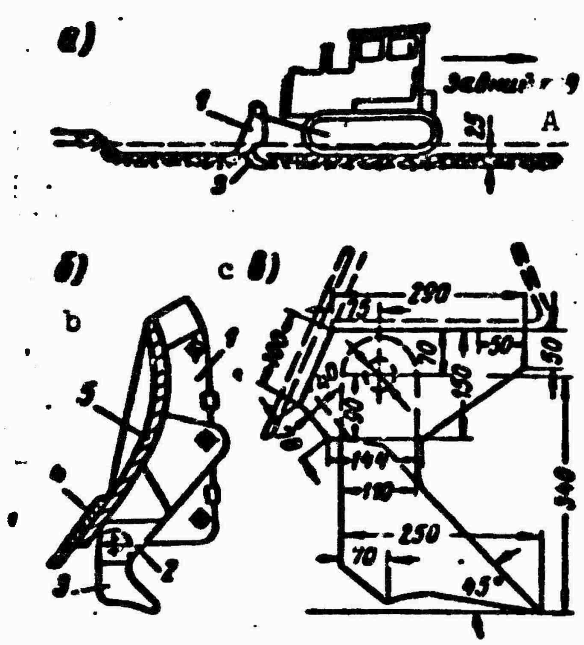


Fig. 26. Scheme of soil cutting by a bulldozer with a ripper (Miroshnichenko's design): a) General view; b) blade with ripper tooth, c) ripper tooth with frame; 1) side wall of blade; 2) frame flange; 3) ripper tooth; 4) blade knife; 5) front wall of blade; A) reverse motion.

The volume of loosened soil should be such that it would ensure continuous work of the bulldozer. It should be kept in mind that loosening the soil to a great depth will result in slipping of the tractor crawlers.

When the topography of the site permits it, the soil must be cut in a manner in which favorable slopes are utilized. This makes it possible to increase the thickness of the soil layer being cut and, consequently, to increase the bulldozer productivity. The relationship showing the increase in bulldozer productivity when working along a favorable slope, is characterized by the following data:

0	2	3	5	10
100	105—107	108—110	115—118	130—135

Moving the Soil

When a bulldozer moves, alongside with filling the blade with soil being cut off, a part of it is lost in the form of two rolls

which form at the blade sides. Despite the relatively small size of these rolls, total loss of soil due to the formation of these rolls are sufficiently large and reach 30-40%. For this reason, in moving the soil it is not only important to achieve a decrease in the [required] time, but also to decrease the soil loss.

When excavating cuts at the airfield, it is practically impossible to supplement the soil lost by additional cutting off while moving it, since this is not required. Consequently, in order to increase the bulldozer productivity, measures must be taken for maximum prevention of losses.

Soil losses on moving can be decreased if the bulldozer moves in a trench and if the bulldozers work in pairs.

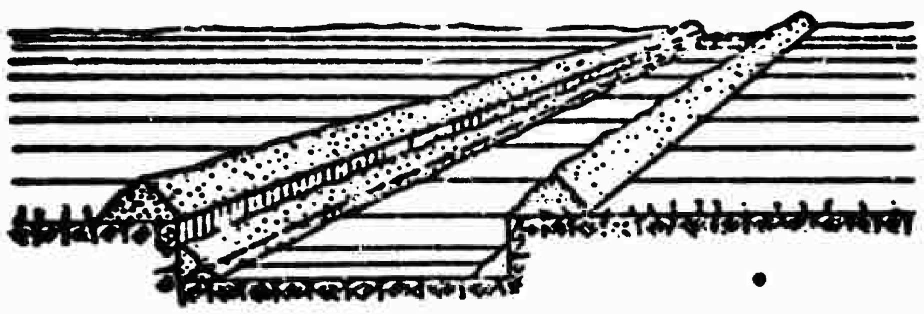


Fig. 27. Trench cut through in the soil by a bulldozer.

The substance of the trench method consists in the fact that the bulldozer cuts a trench whose width is equal to the blade length, by making several passes over the same route. The soil is, subsequently, moved along it, and the side walls of the trench prevent soil losses from the blade (Fig. 27).

If the earth moving plan does not provide for excavation of that surface over which the soil is to be moved, then the trench is formed by windrowing of soil along the sides of the blade.

Moving of soil in trenches decreases its losses and makes it possible to increase the volume of soil moved ahead by the blade by ap-

proximately a factor of 1.5.

Each new trench is cut parallel to that previously made at a distance of 0.4-0.8 meters. The soil remaining between two trenches is cut off after the neighboring trench has been cut.

This method of moving the soil increases the bulldozer productivity by 10-30% (depending on the hauling distance).

The disadvantage of the trench method is the lowering of the return speed of the bulldozer along the trench. For this reason, when soil is moved through a distance of 30-50 meters, the bulldozer should return outside the trench.

Paired bulldozer operation consists in the fact that when the hauling distance is more than 50 meters, the soil is moved by two bulldozers moving alongside one another (Fig. 28). Here, the soil loss is decreased by a factor of two in comparison with losses of singly operating bulldozers, since practically no soil penetrates in the space between the two blades. The two blades in this case are filled as one of double the length.

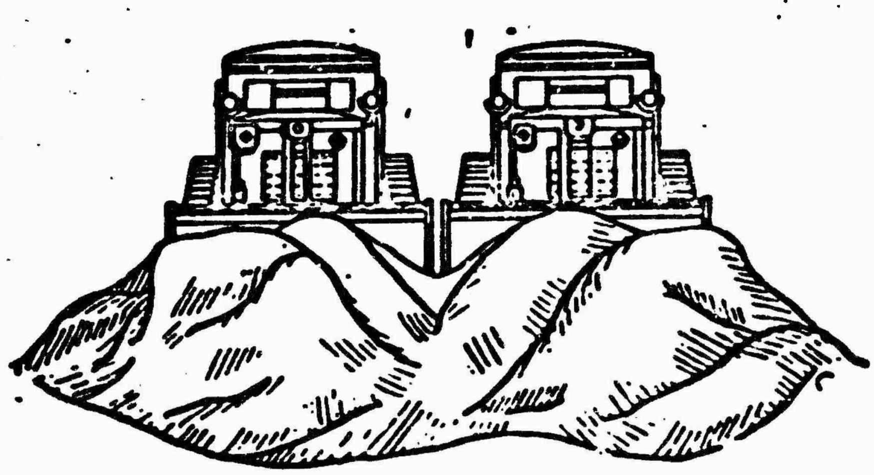


Fig. 28. Scheme of paired bulldozer operation.

The disadvantage of the paired method of bulldozer operation is the certain difficulty in performing it, since this requires synchronized work by the operators. The distance between blades should not

exceed 20-30 cm in loose soils and 50 cm in cohesive soils.

The bulldozer productivity can be considerably raised by mounting side flanges (wings) on the blade, which not only cut losses but increase the soil volume moved by the bulldozer by approximately a factor of 1.5-1.7; here, the speed is decreased only by 10-15%.

The wings are usually rigidly fastened to the side walls of the blade, here, the lower edge of the wings is fastened above the cutting edge of the knife. The disadvantage of rigidly fastened wings are possible breakage in bulldozing hard soils and certain losses of soil during moving it.

In airport construction, the bulldozer is used in soils with varying cutting difficulties. In connection with the suggestion of workers of the SoyuzdorNII and other authors about making wings which will be fastened parallel to the tractor motion axis and of wings which would be hinged to the bulldozer blade, merit attention.

Wings hinged to the blade can be fixed in three different positions (Fig. 29): in excavating hard soils, the wings do not participate in the work (Fig. 29a); in working in light soils, the wings are placed parallel to the direction of tractor motion (Fig. 29b) and, in addition, the wings can be placed at a 45° angle to the direction of motion (Fig. 29c).

The Kiev Construction Engineering Institute has elaborated a design of a scoop shaped bulldozer blade. The scoop shape of the blade increases the volume of soil being moved by a factor of 1.7-1.8 in comparison with the standard blade and also improves the lowering it into the soil. The scoop shape of the blade forces the cut soil to move toward the longitudinal axis of the bulldozer, thus eliminating losses from the blade edges, which makes it possible to use bulldozers in moving soil over distances larger than 100 meters.

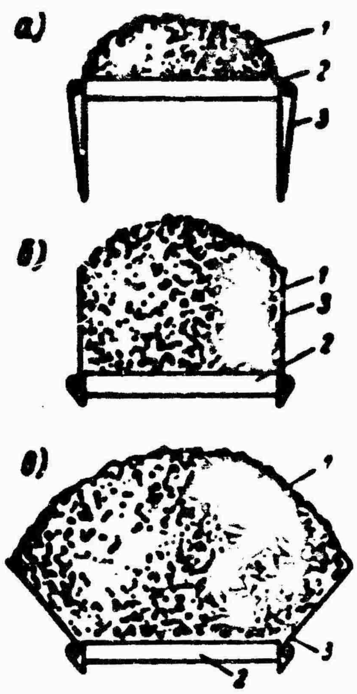


Fig. 29. Wings hinged to the blade: 1) Soil being moved; 2) blade; 3) wings.

In excavating cuts, use is made of bulldozer movement schemes by strips or straight ahead. Excavating cuts by strips is the more extensively used scheme. In each cycle, the bulldozer moves soil from the cut to the fill and return to the cut in reverse gear.

If the cuts are situated to both sides of a fill, then the bulldozer, having moved soil into the fill, levels out the soil by gradually raising the blade, then moves over to the oppositely located cut where, turning about, it again takes a cut. The time for turns is here spent needlessly.

The return of the bulldozer in reverse to the point of excavation is economically advantageous, if the following unequality is satisfied:

$$\frac{l_1 + l_2}{v_z} - 2t_{dop} < \frac{l_1 + l_2}{v_{max}} - 2t_{pov}.$$

where l_1 is the length of soil loading section, meters; l_2 is the length of the soil moving section, meters; v_z is the speed with which the bulldozer moves in reverse, meters/sec; t_{dop} is the time for shifting gears, sec.; v_{max} is the bulldozer speed in highest gear, meters/sec; t_{pov} is the time spent by the bulldozer in making a turn, sec.

Turning the bulldozer around for returning to the excavation point is expedient only when soil is moved through distances in excess of 75-100 meters.

Straight bulldozing is used when earth moving is performed in small sections, when cuts and fills alternate.

The trench method of bulldozing is applicable to the above schemes, here depending on the distance an intermediate windrow may, or may not, be used in moving the soil.

In trench moving of soil withoutaan intermediate windrow, each strip (whose width is equal to the blade length) is excavated immediately to the design elevations (if these are moderate), and when an intermediate windrow is used, the soil is first moved into it, and then into the fill to the point of placement. The distance to the windrow is marked off in 20-25 meters.

If the fill is adjacent to the cut and if the soil hauling distance is 20-30 meters, it is advantageous to use a scheme in which the soil is moved in larger batches, which was suggested by the innovating bulldozer operator I.Ye. Doronin. In working according to this scheme, first the first batch of soil is moved to the foot of the fill, and in the succeeding pass it is, together with a second batch, moved into the fill. This method cuts the time used in a working cycle of a bulldozer by 10-15%.

Unloading the Soil

The soil is usually unloaded by layers, for which purpose the blade is raised slightly, and the forward tractor motion produces a level soil of layer of the required thickness. The duration of the unloading operation is related to the method by which it is achieved and can be decreased mainly by combining it in time with moving the soil or with the return bulldozer trip. The bulldozer blade is unloaded starting with the nearest edge of the fill.

14. EXCAVATING CUTS BY ELEVATING GRADERS

The elevating grader is used to best advantage for excavating long and shallow cuts at a relatively uniformly shaped site. The basic virtue of the elevating grader consists in its high productivity

which is achieved by continuous operation. The elevating graders are most productive when working in cohesive soils with an optimal moisture content. The productivity of elevating graders, when working in loose (sand, duty loess, etc.) and also in moist and sticky soils is low, consequently, their use under these conditions is not efficient.

Elevating graders cannot work in soils containing roots, stones and boulders and also in gravel soils.

In airport construction, use can be made of the D-192 and GEM elevating graders coupled to the S-80 tractor, of the D-369 self-powered elevating grader (Fig. 30) and of the [tractor] mounted elevating grader.

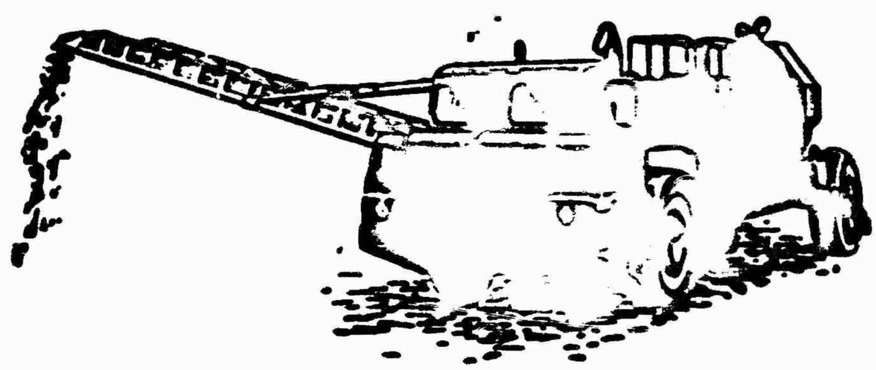


Fig. 30. Self-powered elevating grader with a diesel electric drive.

The soil is excavated by layers along the entire width of the cut by longitudinal passes of the elevating grader. The thickness of the layer being cut depends on the diameter of the cutting disk and on the soil category. Head soils must first be loosened. In addition, prior to commencing operations at the given section, it is necessary to make it passable to the elevating grader for which reason all holes are filled, and stumps, brushwood and even stones and boulders are removed. The optimal coverage length should not be less than 500 meters. Then, the time lost in turns will comprise 5-6%.

An open cut must be prepared for the first passage of the elevat-

ing grader. To ensure proper direction of motion, during the first passages of the elevating grader, stakes are fixed or pegs placed along the direction of motion, which serve as guidelines. The elevating grader is turned around outside the limits of the cut, here, the disk and the lower part of the conveyer are lifted.

The cutting disk is fixed, depending on the category of the excavated soil. The recommended cutting angle α (Fig. 31a) for clay soils is 20°, for argillaceous soils it is 25° and for sandy loam soils it is 35°. The coverage angle β (Fig. 31b) varies from 40 to 55° (the smaller values are for hard soils and the small for light soils).

The soil can be moved to the cut by dump trucks and tractor pulled trailers, here, it is desirable to use dump trucks with a large body capacity or tractor trains consisting of several high capacity trailers.

The dump trucks (or tractor trains) drive up from the side beneath the upper end of the conveyer and, moving parallel to the elevating grader at the same speed as the latter, are gradually filled with soil. When the dump truck is filled, it moves out ahead and the following truck moves in to be loaded. When the transportation facilities replace one another, the elevating grader is stopped but the disk is not lifted out from the ground.

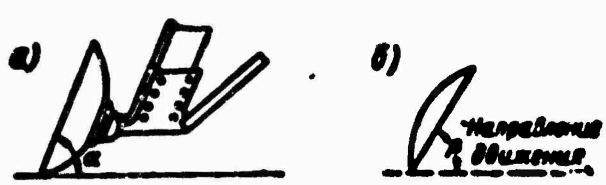


Fig. 31. Positioning the cutting disk of an elevating grader. 1) Direction of motion.

15. QUARRYING OF CUTS BY EXCAVATORS

The use of excavators for quarrying of cuts at the airfield is economically advantageous for large and concentrated volumes of earth moving operations with average elevations of cut depth not less than 1.0 meters, and also in removing the peat layer.

In airport construction, use is made of general purpose single bucket excavators with a bucket capacity from 0.25 to 3.0 meters^3, with a 360° radius of rotation. The fact that the working equipment of a general purpose excavator is easily changed makes it possible to effectively use excavators in earth moving and ground clearing work of different character.

The use of excavators depends on the conditions, character and schedule for performing the operations, their volume and on the soil type.

A power shovel [excavator] is most widely used in digging of deep cuts with loading of the soil onto transportation facilities. Excavators with this equipment are used for making cuts in land situated above the surface at which they stand. The minimal height of cut which ensures complete filling of the bucket at the time it is lifted depends on the bucket capacity and on the density of the dug soil.

When working with a height lower than that recommended complete filling of the bucket requires secondary scooping, and, as a safety measure, excavators should not work in cuts exceeding the maximal scooping height, since an overhang is created in this case, which may result in caving in of the pit wall.

Working parameters of excavators equipped with a power shovel are given in Table 8.

Dragline-equipped excavators are less frequently used in excavating cuts at airports. They excavate soil below the level at which they

stand. For this reason it is more advantageous to use draglines in working in raw pits and when it is necessary to remove weak soil, discovered on the future unpaved or paved area of the airfield. The dragline work in hard soils is complicated and requires preliminary loosening. The pit depth for a dragline has limits established by the boom length and by the angle at which the cut is excavated. The depth of the cut should also ensure filling of the bucket.

Working parameters of dragline-equipped excavators are given in Table 9.

It should be noted that the working cycle of a dragline is longer than the cycle of a power shovel of the same capacity, and in loading the soil it is necessary to center the bucket over the body of transportation facilities, for which reason the productivity of a dragline is lower than the productivity of a power shovel of the same type.

The use of a <u>clamshell excavator</u> is expedient only in removing peat deposits, for which reason it is comparatively seldom used in airport construction.

The productivity of excavators is calculated by the formula

$$\Pi = \frac{qTK_{1}}{t_{ts}} \text{ meters}^3\text{/shift}$$

where T is the duration of the shift, hours; q is the solid soil volume, meters^3, grabbed by the excavator in a single pass; K_1 is the time utilization coefficient during the shift (0.80-0.85); and t_{ts} is the time used up by the excavator in one shift, hours.

Earth moving operations performed by an excavator consist of making the cut, moving the soil to the filling point (to the fill), and filling the soil in the fill.

In organizing the entire integrated set of excavator operations it is necessary to properly plan the performance of each element of

the operations and to ensure interconnection of all elements into a continuous integrated process.

TABLE 8

Рабочие параметры экскаваторов 1	2 Марка экскаватора (оборудован прямой лопатой)				
	Э-2002 3		Э-1004, Э-1252 3		Э-505, Э-6… 3
	4 Угол наклона стрелы, град.				
	45	60	45	60	45
Наибольший радиус резания на уровне напорного вала, м 5	11,5 / 10,4	10,8 / 9,7	9,8 / 8,8	9 / [illegible],1	7,9 / 7,[illegible]
Наименьший радиус резания на уровне напорного вала, м 6	7,9 / 7,9	7,2 / 7,2	6,9 / 6,9	6,1 / 6,1	5,2 / 5,2
Наибольший радиус резания на уровне стояния экскаватора, м 7	7,4 / 6,6	6,25 / 5,6	6,4 / 5,8	5,7 / 5,1	4,8 / 4,3
Наименьший радиус резания на уровне стояния экскаватора, м 8	— / 4	— / 4	3,3 / 4,3	3,6 / 3,6	2,5 / 2,5
Наибольший радиус разгрузки, м 9	10,7 / 9,6	10 / 9	8,7 / 7,8	8 / 7,2	7,2 / 6,5
Высота разгрузки (при наибольшем радиусе разгрузки), м 10	3,75 / 3,4	4,7 / 4,2	3,3 / 3	3,7 / 3,4	2,6 / 2,3
Наибольшая высота разгрузки, м 11	6 / —	7,6 / —	5,5 / —	6,8 —	4,6 / —
Радиус разгрузки при наибольшей высоте разгрузки, м 12	10,2 / —	8,5 / —	8 / —	7 / —	6,6 / —
Высота резания, м: 13					
14 наименьшая по условиям наполнения ковша:					
15 песчаный грунт	— / 2	— / 2,0	— / 2	— / 2	— / 1,5
16 глинистый грунт	— / 3,25	— / 3,25	— / 2,5	— / 2,5	— / 2
17 взорванная скала	— / 3,75	— / 3,35	— / 3	— / 3	— / 2,[illegible]
наибольшая 18	9,3 / 6,1	10,8 / 6,7	8 / 5	9 / 5,4	6,6 / 4,[illegible]
Ширина проходки, м: 19					
наименьшая 20	— / 8,4	— / 8,4	— / 6,6	— / 6,6	— / 5,[illegible]
наибольшая 21	— / 13,2	— / 11,2	— / 11,6	— / 10,2	— / 8,[illegible]
оптимальная: 22					
при погрузке в автомобильный транспорт 23	— / 10,6	— / 9,9	— / 8,7	— / 8	— / 6,[illegible]
24 при погрузке в железнодорожный транспорт	— / 11,1	— / 10,4	— / 9,2	— / 8,5	—
25 то же, по узкой колее	— / 9	—	— / 9,4	— / 8,2	— / 6
Длина рабочей передвижки экскаватора, м 26	— / 2,6	— / 2,6	— / 2,5	— / 1,5	— / 1[illegible]
Расстояние от оси транспортного пути до оси движения экскаватора при оптимальной ширине проходки, м: 27					
при автомобильном транспорте 28	— / 6,6	— / 6,6	— / 5,6	—	— / 5
при железнодорожном узкой колеи 29	—		— / 5,6	—	— / 5
Радиус хвостовой части кабины экскаватора, м 30	4,2 / —	4,2 / —	3,3 / —	3,3 / —	2,9 / —

1) Working parameters of excavators; 2) excavator (power shovel) brand; 3) E-2002; 4) angle of inclination of the boom, degrees; 5) greatest cutting radius at the head wall level, meters; 6) smallest cutting radius at the head wall level, meters; 7) greatest cutting radius at the level of excavator position, meters; 8) smallest cutting radius at the level of excavator position, meters; 9) greatest dumping radius, meter. 10) dumping height (for the greatest dumping radius), meters; 11) greatest dumping height, meters; 12) dumping radius for the greatest dumping height, meters; 13) cutting height, meters:; 14) smallest which will re

…re interconnection of all elements into a …cess.

		2 Марка экскаватора (оборудован прямой лопатой)							
		Э-2002 3		Э-1004, Э-1252 3		Э-505, Э-651, Э-652, Э 656		Э-258 3	
		4 Угол наклона стрелы, град.							
		45	60	45	60	45	60	45	60
7,1	…орного	11,5 /10,4	10,8 / 9,7	9,8 / 8,8	9 / 8,1	7,9 / 7,1	7,3 / 6,6	3,8 / 3,2	5,3 / 4,6
5,2	…орного	7,9 / 7,9	7,2 / 7,2	6,9 / 6,9	6,1 / 6,1	5,2 / 5,2	4,6 / 4,6	—	—
4,3	…стенки	7,4 / 6,6	6,25/ 5,6	6,4 / 5,8	5,7 / 5,1	4,8 / 4,3	4,3 / 3,9	3,9 / —	3 ;
2,5	…стенки	— / 4	— / 4	3,3 / 3,3	3,6 / 3,6	2,5 / 2,5	2,8 / 2,8	—	—
6,5		10,7 / 9,6	10 / 9	8,7 / 7,8	8 / 7,2	7,2 / 6,5	6,6 / 5,9	5,4 / 4,8	4,8 / 4,3
2,35	…се раз-	3,75/ 3,4	4,7 / 4,2	3,3 / 3	3,7 / 3,4	2,6 / 2,35	3 / 2,7	2,3 / 2	2,8 / 2,5
—		6 / —	7,6 / —	5,5 / —	6,8 —	4,6 / —	5,7 / —	3,4 / —	4,3 / —
—	…ге раз-	10,2 / —	8,5 / —	8 / —	7 / —	6,6 / —	5,5 / —	5,2 / —	4,5 / —
/ 1,5	…ниже:	— / 2	— / 2,0	— / 2	— / 2	— / 1,5	— / 1,5	— / 1,0	— / 1
/ 2		— / 3,25	— / 3,25	— / 2,5	— / 2,5	— / 2	— / 2	— / 1,5	— / [illegible]
/ 2.		— / 3,75	— / 3,75	— / 3	— / 3	— / 2,5	— / 2,5	—	
/ 4.		9,3 / 6,1	10,8 / 6,7	8 / 5	9 / 5,4	6,6 / 4,2	7,9 / 4,8	3,2 / —	[illegible] / —
/ 5.		— / 8,4	— / 8,4	— / 6,6	— / 6,6	— / 5,6	— / 5,8	[illegible]	— / 4,5
/ 8.		— /13,2	— /11,2	— /11,6	— /10,2	— / 8,6	— / 7,8	/ 6,0	—
/ 6.	…порт 25	— /10,6	— / 9,9	— / 8,7	— / 8	— / 6,8	—	— / 5	—
—	…ранспорт	— /11,1	— /10,4	— / 9,2	— / 8,5	—		—	—
/ 6		— / 9	—	— / 9,4	— / 8,2	— / 6,8	[illegible] 7	—	—
/ 1	…м 26	— / 2,6	— / 2,6	— / 2,5	— / 1,5	— / 1 [illegible]	— / 1,1	— / 2,2	— / 1,6
	…до оси …ширу-								
- / 5		— / 6,6	— / 6,6	— / 5,6	—	/ 5	—	— / 4,8	— / 4,5
- / 5				— / 5,6	—	— / 5	—	—	—
0 / -	29	—							
	…ора, м 30	4,2 / —	4,2 / —	3,3 / —	3,3 /	2,9 / —	2,9 / —	2,3 / —	2,3 / —

…xcavators; 2) excavator (power s… …el) brand; …lination of the boom, degrees; … greatest … wall level, meters; 6) smalle… cutting rad-…, meters; 7) greatest cutting …adius at the …n, meters; 8) smallest cutti… radius at the …n, meters; 9) greatest dump…g …adius, meters; …e greatest dumping radius), …e…ers; 11) great-…; 12) dumping radius for the greatest dumping …ng height, meters:; 14) sma… est which will re-

sult in filling the bucket; 15) sandy soil; 16) clay soi[illegible] pulverized by explosives; 18) greatest; 19) width of pas[illegible] smallest; 21) greatest; 22) optimal; 23) in loading onto in loading onto railroad cars; 25) the same as above, fo[illegible] 26) length of the working movement of the excavator, met[illegible] distance from the axis of transportation path to the axi[illegible] movement for the optimal passing width, meters; 28) when 29) when using narrow gauge railroad; 30) radius of the [illegible] excavator cab, meters.

TABLE 9

1 Рабочие параметры экскаватора	2 Марка экскаватора					
	3 Э-2002					
	4 Емкость ковша, м³					
	2		1,5			
	5 Длина стрелы, м					
	15		20		12,5	
	6 Угол наклона стрелы					
	30	15	30	45	30	[illegible]
7 Наибольший радиус резания на уровне стоянки, м:						
8 по паспорту с забросом ковша	17,4	15,8	22,4	20,3	14,3	[illegible]
9 оптимальный	15,8	13,6	20,2	17,4	13,3	[illegible]
10 Наименьший радиус резания на уровне стоянки, м	4	4	4	4	3,3	[illegible]
11 Оптимальный радиус резания, м, на уровне подошвы забоя при заложении откоса 1:1 и глубине:						
12 1,75 м	—	—	—	—	—	[illegible]
2,5 »	15,95	13,77	20,42	17,61	13,45	[illegible]
3,0 »	15,98	13,81	20,45	17,65	13,3	[illegible]
4,0 »	16,05	13,87	20,53	17,71	13,6	[illegible]
5,0 »	16,12	13,95	20,60	17,78	13,7	[illegible]
6,0 »	16,19	14,01	20,66	17,85	13,8	[illegible]
7,0 »	16,26	14,08	20,74	17,92	—	[illegible]
8,0 »	16,33	15,15	20,81	17,99	—	[illegible]
13 Наименьший радиус резания, м, на уровне подошвы забоя при глубине:						
14 1,75 м	—	—	—	—	—	[illegible]
2,5 »	6,5	6,5	6,5	6,5	6	[illegible]
3,0 »	7	7	7	7	6,3	[illegible]
4,0 »	8	8	8	8	7,3	[illegible]
5,0 »	9	9	9	9	8,3	[illegible]
6,0 »	10	10	10	10	9,3	[illegible]
7,0 »	11	11	11	11	—	[illegible]
8,0 »	12	12	12	12	—	[illegible]

1) Working parameters of the excavator; 2) brand of drag excavator; 3) E-2002; 4) bucket capacity, meters³; 5) bo[illegible] ters; 6) angle of inclination of boom, degrees; 7) great[illegible] dius at the level of standing, meters; 8) according to t[illegible] with the bucket throw; 9) optimal; 10) smallest cutting level of standing, meters; 11) optimal cutting radius, m[illegible] level of the pit base when producing a 1:1 slope and for meters; 13) smallest cutting radius, meters, at the leve[illegible] for a depth:.

Excavating cuts with Power Shovels

When using power shovels, the soil in cuts is excav[illegible] wise, through side cuts. The substance of this method co[illegible]

bucket; 15) sandy soil; 16) clay soil; 17) rock
lves; 18) greatest; 19) width of pass, meters; 20)
st; 22) optimal; 23) in loading onto trucks; 24)
road cars; 25) the same as above, for narrow gauge;
rking movement of the excavator, meters; 27) the
is of transportation path to the axis of excavator
imal passing width, meters; 28) when using trucks;
w gauge railroad; 30) radius of the tail part of
s.

	Марка экскаватора, оборудованного драглайном															
	Э-2002				Э-1252				Э-1004				Э-505, Э-651, Э-652, Э-656			
экскаватора	Емкость ковша, м³															
	2		1,5		1				1				0,5			
	Длина стрелы, м															
	15		20		12,5		15		13		16		10		13	
	Угол наклона стрелы, град.															
	30	45	30	45	30	45	30	45	30	45	30	45	30	45	30	45
уровне стоянки, м: ковша	17,4	15,8	22,4	20,3	14,3	12,9	16,8	15,2	14,4	13,2	17,5	16,2	11,1	10,2	14,3	13,2
	15,8	13,6	20,2	17,4	13,3	11,3	15,4	12,8	13,4	11,5	15,1	13,3	10,3	8,7	12,9	10,9
в уровне стоянки, м	4	4	4	4	3,5	3,5	3,5	3,5	3,5	3,5	3,5	3,5	3	3	3	3
м, на уровне по- откоса 1:1 и глу-	—	—	—	—	—	—	—	—	—	—	—	—	10,4	8,8	13	11
	15,95	13,77	20,42	17,61	13,45	11,45	15,4	12,9	13,55	11,75	16,1	13,9	10,5	8,9	13,1	11,1
	15,99	13,81	20,45	17,65	13,5	11,5	15,45	13,0	13,6	11,78	16,15	14	10,55	8,95	13,15	11,2
	16,05	13,87	20,53	17,71	13,6	11,55	15,55	13,1	13,7	11,85	16,2	14,1	10,6	9	13,2	11,2
	16,12	13,95	20,60	17,78	13,7	11,6	15,6	13,15	13,8	11,9	16,3	14,15		—	—	—
	16,19	14,01	20,66	17,85	13,8	11,7	13,7	13,2	13,9	12	16,4	14,2		—	—	—
	16,26	14,08	20,74	17,92	—	—	—	—	—	—	—	—	—	—	—	—
	16,33	15,15	20,81	17,99	—	—	—	—	—	—	—	—	—	—	—	—
м, на уровне поло-	—	—	—	—	—	—	—	—	—	[illegible]	—	—	4,75	4,75	4,75	4,75
	6,5	6,5	6,5	6,5	6	6	6	6	6	[illegible]	6	6	5,5	5,5	5,5	5,5
	7	7	7	7	6,3	6,3	6,3	6,3	6,3	[illegible]	6,5	6,5	6	6	6	6
	8	8	8	8	7,3	7,5	7,3	7,3	7,3	[illegible]	7,5	7,5	7	7	7	7
	9	9	9	9	8,3	8,5	8,3	8,3	8,3	[illegible]	8,5	8,5	—	—	—	—
	10	10	10	10	9,3	9,3	9,3	9,3	9,3	[illegible]	9,5	9,5	—	—	—	—
	11	11	11	11	—	—	—	—	—	—	—	—	—	—	—	—
	12	12	12	12	—	—	—	—	—	—	—	—	—	—	—	—

of the excavator; 2) brand of dragline-equipped
; 4) bucket capacity, meters³; 5) boom length, me-
lination of boom, degrees; 7) greatest cutting ra-
standing, meters; 8) according to the nameplate
; 9) optimal; 10) smallest cutting radius at the
ters; 11) optimal cutting radius, meters, at the
when producing a 1:1 slope and for the depth:; 12)
cutting radius, meters, at the level of the pit

Power Shovels

shovels, the soil in cuts is excavated by length-
its. The substance of this method consists in the

fact that the cut is excavated by lengthwise passes with loading of the soil into transportation facilities, whose routes are situated alongside the cut parallel to the excavator motion (Fig. 32).

Roads used for hauling away the soil are situated either at the same level as the cut base or, which is better, slightly higher. It is not expedient to place the roads lower than the base of the pit, since in this case the transportation facility will be subjected to large dynamic loads due to impact of the dumped soil and, in addition, the roads will inevitably be blocked by soil.

The width of the pit is established in accordance with the cutting and unloading radii. It is usually taken as being equal to the cutting radius.

The distance between the loading roads and the axis of excavator movement should be as small as possible, i.e., just enough not to restrict the work of the excavator by the necessity of unloading the soil at minimal dumping radii.

To decrease the time used up in moving, it is required that the greatest possible soil volume be excavated from a single excavator stand, which for a given depth and width of pit is achieved by increasing the length of excavator displacement. The soil should be loaded onto the bucket in thick layers with maximal utilization of the engine capacity.

In working the cuts by through lengthwise passes the excavator, having made a face cut on the section assigned to it, turns around and makes the next face cut in the opposite direction (Fig. 33). When it is necessary to concentrate several excavators in a single cut, the cuts in the plane are made in steps.

Cuts at the airfield are usually worked by excavators together with other earth digging machines, performing auxiliary operations in preparing the working area for the excavators. The soil from the edges

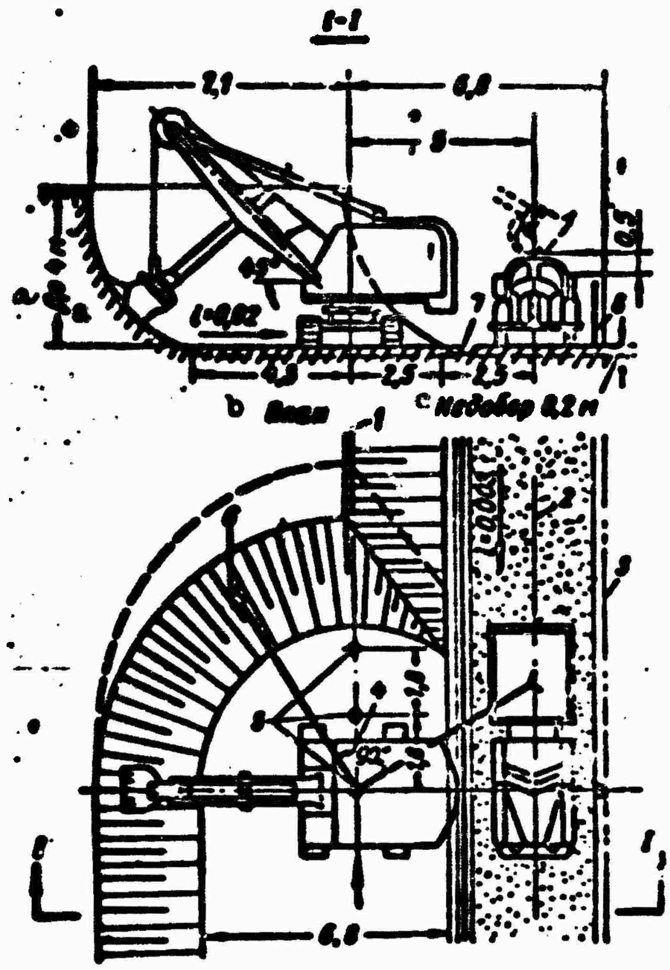


Fig. 32. Scheme of quarrying a cut by the E-505 excavator with loading of the soil into dump trucks:; 1) axis of excavator pass; 2) axis of dumping truck movement; 3) axis of the preceding excavator pass; 4) average turning angle; 5) excavator stand area; 6) center of gravity of the cut; 7) water draining ditch; 8) boundary stake; a) Up to 4 meters; b) plan; c) remainder 0.2 meters.

of the cut to the standard facing height is first cut off by scrapers or bulldozers.

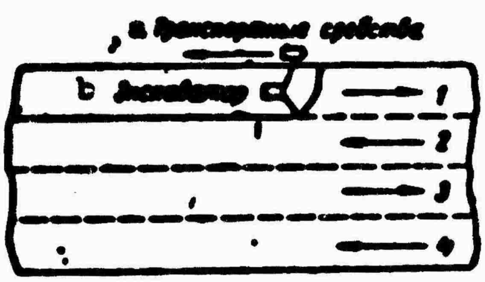


Fig. 33. Working of cuts by excavators by through, lengthwise face cuts (the operation sequence is given by the numbers). a) Transportation facilities; b) excavator.

At the area designated for excavator work the topsoil layer is first removed by bulldozers. Final cutting of soil in the cut (after the excavator) is performed by scrapers, bulldozers and graders.

In removing soil left over by excavators using bulldozers mounted on S-80 or DT-54 tractors, it is possible to achieve an accuracy of up to 7 cm, and when bull-

dozers are mounted on the "Belarus" tractor the accuracy is up to 4 cm. The remaining soil can also be removed by an excavator equipped with a planing attachment. The surface finish cut to the given elevations is checked by a surveyor's level or by sighting. Excavating below the design elevations is not permitted.

For working cuts shallower than 1.0 meters, it is expedient to use excavators together with bulldozers. Here the bulldozers pile the soil into conical piles, from which the excavator loads them onto transportation facilities.

In working in small pits (1.0-1.5 meters high), the volume of the loaded soil is increased by equipping the bucket with extended teeth.

The limiting pit height is given on the excavator nameplates. But, if the cuts made by the excavator consist of small free flowing sand and there is no danger that the wall overhang will fall down, then the excavator can quarry these soils by making face cuts exceeding the scooping height given in the nameplates.

In the process of working cuts by excavators rapid and complete drainage of surface water into the temporary water drainage system should be ensured. When working in flooded pits using mats and planks the productivity of the excavator is decreased to 0.75-0.85 of the standard productivity.

In working in light soil, in order to fully use the engine capacity the standard bucket should be equipped with side and tail lips of sheet steel, which ensures increasing the excavator productivity by 50-70%. At the present time, buckets with a semicircular bottom and with a cutting edge, the use of which increases the productivity of the excavator by a factor of 1.5-2, are being series produced.

Medium and light soils should be excavated with the excavator [control] lever pushed to the middle position, and hard soils should be

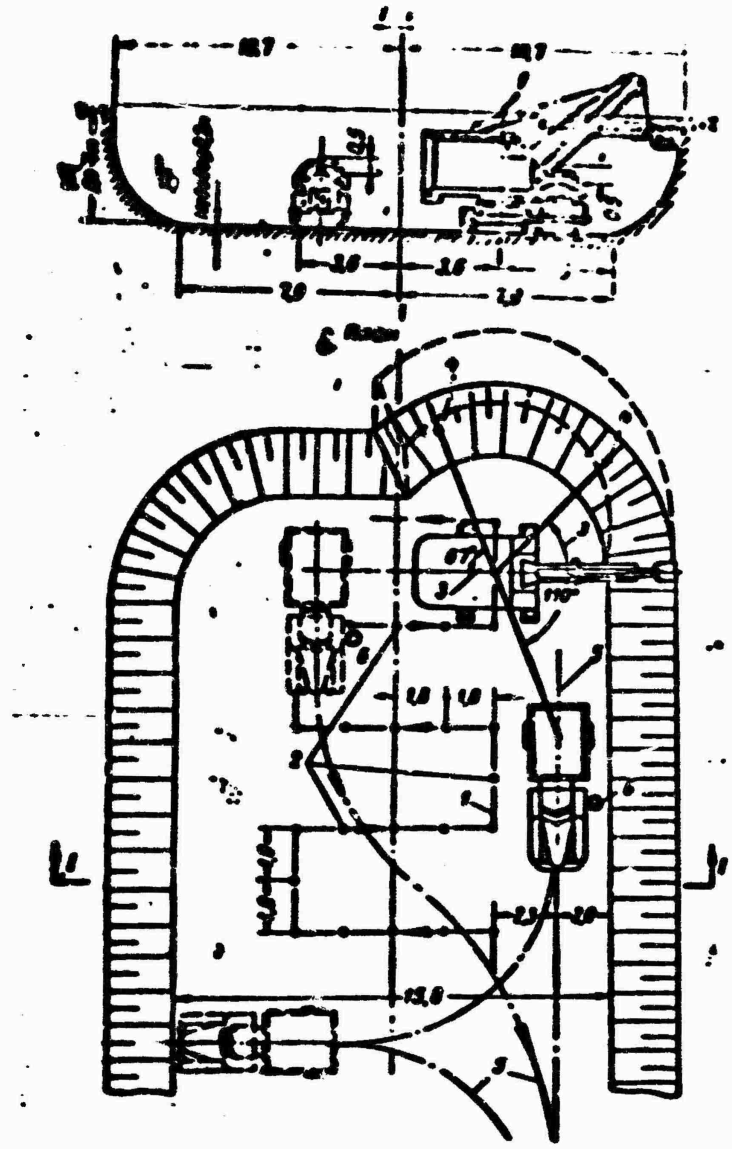


Fig. 34. Scheme for excavating a cut by a widened head fact cut using the E-505 excavator and loading the soil into ZIL-585 dumping trucks: 1) Axis of excavator passage; 2) excavator stands; 3) average turning angle; 4) centers of gravity of the right and left halves of the cut; 5) axis of motion of the dump trucks; 6) boundary stake. a) Up to 4 meters; b) remainder 0.2 meters; c) plan.

worked with the lever overhanging only slightly, which decreases the loading time and provides for complete filling of the excavator bucket.

According to the experience acquired by excavator operators, comrades Chernikhov and Lyutenko, cohesive sticky soils should be unloaded with the lever fully retracted by sharply shaking the bucket. Under these conditions the unloading rate can also be increased by placing vibrators on the bucket walls.

In exceptional cases, when working on steep slopes which make the

building of roads for transportation facilities impossible, it is permitted to use front face cutting of cuts, in which the excavator moves in the pit opened up to its full width, and the transportation facilities upon reaching the pit are turned around and supplied to the excavator in reverse (Fig. 34).

If the pit height exceeds that necessary for filling the bucket, and the soil does not slip down, then it is expedient to make the cut by parts, first working the upper part of the pit to a depth of two-three layers, and then the lower, alternating these operations.

If the soil slips down from the upper part of the pit, then it should be scooped up at the base of the pit (picking up the soil which slipped down).

Under normal conditions, a pit is excavated consecutively moving in the direction away from the point of loading onto the transportation facilities. In hard soil it is expedient to quarry the pit in an alternating order. Rock soils must be first loosened by explosions.

The width to which the rocks should be piled up should be established by the plan of blasting operations. It is recommended that rocky soil be quarried by excavators with a bucket capacity of 1 meter^3 and more.

The excavator productivity drops sharply in quarries containing large boulders. If the boulder is situated at the base of the pit, then the excavator bucket is used to remove the soil from it, and then it is dug out and moved out of the working area. When a boulder is situated at the middle part of the pit, it is removed by a bucket with an open bottom and moved out of the working area.

Cut Operations Using Dragline-Equipped Excavators

A dragline-equipped excavator produces cuts by lengthwise, parallel passes, making face cuts.

The excavator and the transportation facility move parallel to the cut axis (Fig. 35). The transportation facility is placed so that the average turning angle for the excavator boom in loading the bucket should be not more than 65°.

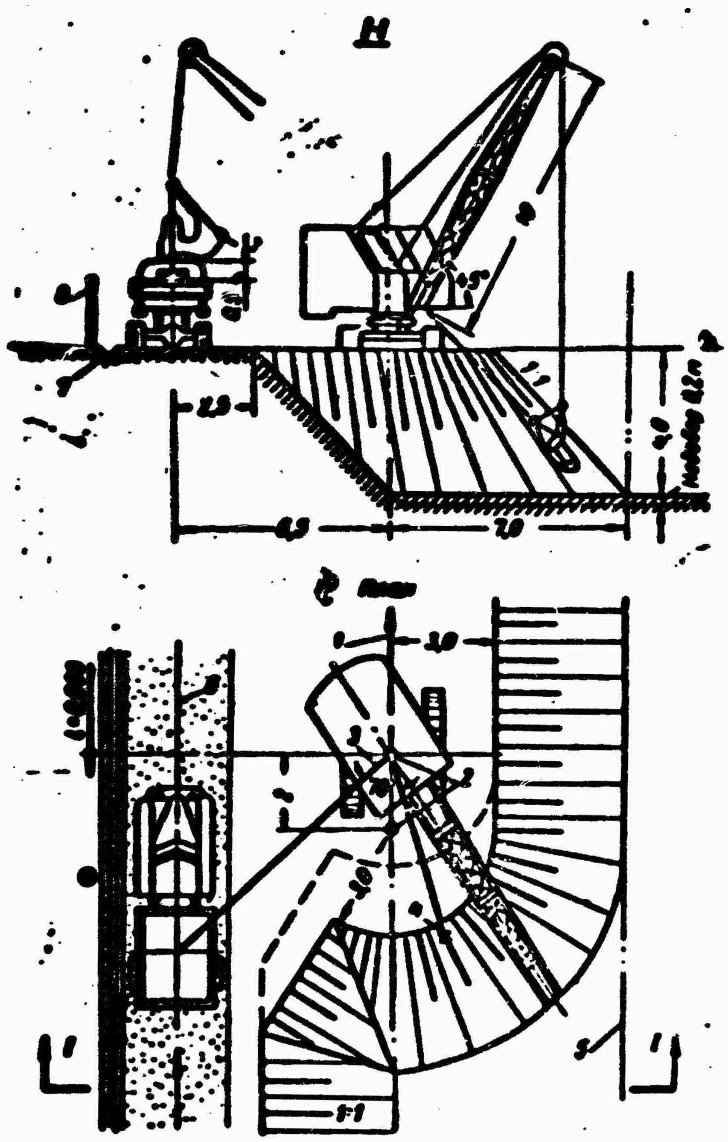


Fig. 35. Scheme of cut operations using the E-505 excavator equipped with a dragline, loading into ZIL-585 dump trucks: 1) Axis of excavator pass; 2) excavator stands; 3) average turning angle; 4) center of gravity of face cut; 5) axis of the preceding excavator pass; 6) axis of motion of the dump truck; 7) water drainage ditch; 8) boundary stake. a) Remainder 0.2 meters; b) plan.

To accelerate the unloading and to protect the dump truck from the dynamic impact of the soil dumped into it, draglines with a bucket capacity of 2.0 meters^3 should be unloaded through a trough, which is moved together with the dragline. The trough is made directly on the construction site.

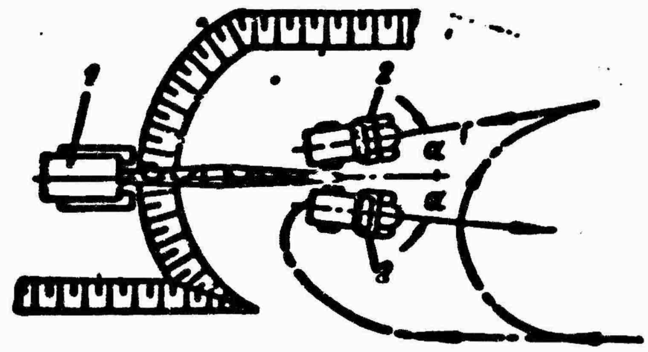


Fig. 36. The shuttle method of soil loading: 1) Excavator (dragline); 2) dump trucks.

In transverse operation the excavator lead is usually taken as 1/3 of the boom length.

At sections at which peat removal is required the excavator is first placed outside the limits of the section on mineral soil, whereupon the first trench is opened, the peat being loaded onto transportation facilities. Immediately after removing the peat, the trench is filled with mineral soil. After the first trench is dug, a second one is opened; here the excavator is placed on the strip created by filling the first trench with mineral soil. The third and each successive trench are excavated in the same sequence. The width of trenches is established depending on the swinging radius of the excavator boom.

Under favorable soil conditions the dragline-equipped excavator operates according to the shuttle system, in which it is stationed on top, at the middle of the cut, and the soil is excavated along the width of the cutting radius from one as well as two sides of the longitudinal axis. Dump trucks are placed at the bottom of the pit successively along its entire length (Fig. 36). After the soil has been excavated from one stand the excavator is moved to the next position.

At the new stand the excavator first works in accordance with the above transverse-shuttle scheme, and then, when a free space is formed between the back wall of the cab and the bottom of the facing slope, it

is possible to lower the bucket ahead of it and to work according to the longitudinal-shuttle scheme without turning the excavator boom. In this case, the dump trucks are placed in a row for receiving the soil. The longitudinal-shuttle loading scheme eliminates turning the boom in loading of one dump truck.

<u>Hauling the Soil</u>

The most widely used facilities for hauling the soil in airport construction into a fill when working with excavators are tractor trailers, soil hauling carts with a single axle pull car, dump trucks and conveyers. Narrow gauge railroad facilities can also be used.

The transportation facilities should be driven in for loading on a strict schedule, so as to ensure continuous work of the excavator. An efficient capacity of the body of a transportation unit should be by a factor of three or four greater than the capacity of an excavator bucket with a capacity of more than 0.5 $meters^3$, and by a factor of five or six greater for bucket capacities less than 0.5 $meters^3$.

In choosing transportation facilities, the distance of soil hauling, amount of cut and fill, the topography of the locality, character of soil at the airfield involved in the operations, the time of the year and the meteorological conditions are considered.

<u>Tractor trailers</u> are most efficient when used at hauling distances of 200-500 meters.

Technical characteristics of tractor trailers which are used are given in Table 10.

The D-179A tractor trailer is towed by the S-80 tractor, and the trailer is unloaded in motion (bottom unloading). The soil dumped from the trailer is a trapezoidal pile 0.5 meters high, with a top width of 0.7-0.8 meters and a bottom width of 1.1-1.3 meters.

The E-505 excavator loads a trailer in 6-7 minutes. The dumping of

TABLE 10

Наименование показателей	Показатели по маркам прицепов		
	Д-179А	Д-258	Д-401
Емкость кузова, м³:			
геометрическая	9	12	14
с шапкой	12	15	17
Погрузочная высота по борту кузова, м	2,24	2,32/2,67 (без [illegible])	3,0
Размеры кузова поверху, м:			
длина	3,55	3,12	4,85
ширина	2,65	2,95	1,90
Дорожный просвет, м	0,50	0,51	0,66
Колесная база, м	4,80	6,20	5,60
Шины колесного хода:			
размер, дюймы	14,00—20	18,00—28	18,00—28
количество, шт.	6	4	4
Вес, кг	8300	12 200	12 363
Необходимый тягач	С-80	С-80 или ДТ-140	

1) Designation of indicators; 2) indicators for trailer brands; 3) D; 4) body capacity, meters^3; 5) geometric; 6) heaped; 7) loading height along the side of the body, meters; 8) without side panels; 9) outside dimensions of body, meters; 10) length; 11) width; 12) road clearance, meters; 13) wheel base, meters; 14) width of wheel tracks:; 15) dimension, inches; 16) number, pieces; 17) weight, kg; 18) required tractor; 19) S; 20) S-80 or DT-140.

loose or weakly cohesive soil from the trailer takes 23-27 seconds, the path length being about 20 meters. Under good soil conditions, the S-100 tractor can two two trailers.

The D-258 tractor-drawn trailer can be unloaded from both sides, which is of advantage if it is necessary to unload the hauled soil to the side of the delivery road. The D-258 trailer is drawn by the S-100 or S-80 tractors, equipped with a hydraulic drive for operating the body tilting hydraulic cylinders.

The D-401 tractor is designed for work with the S-100 tractor. This trailer is unloaded by tilting the body backward.

The velocity of loaded trailers over good earth hauling roads does not exceed 5-6 kilometers/hour, for which reason their productivity drops sharply with increasing hauling distances.

Soil hauling carts with single axle pull cars are efficient when the soil hauling distance is 0.5-2.0 kilometers. The D-504 earth hauling cart has a body with the capacity of 10 meters^3. The fact that it

is provided with high-passability tires ensures a velocity up to 35-40 kilometers/hour for the pull car and the cart. The aforementioned carts can move over soil or dirt roads, which were only slightly treated and graded.

Dump trucks are used when the hauling distance is 1.5-2.0 kilometers and more. The basic merits of dump trucks are high speed and maneuverability, a small turning radius and the ability to drive up comparatively steep grades. Excavators with bucket capacity from 0.25 to 0.8 meters^3 are most expediently used with dump trucks with a weight capacity up to 5-7 tons (MAZ-205), excavators with 1.0-1.5 meters^3 capacity are best used with 7-10 dump trucks (YaAZ-210) and excavators with a bucket capacity from 2 to 3 meters^3 are most expediently used with 10-25 ton capacity dump trucks (YaAZ-210, MAZ-525).

Technical characteristics of dump trucks are given in Table 11.

The decisive condition which ensures normal work of automotive transportation facilities is the availability of good roads. Roads laid out on sand or gravel soil are suitable only in the dry time of the year. The road surface part used for driving must be reinforced in the rainy period.

Approach roads should be maintained in serviceable condition by systematic grading and water drainage.

Link conveyers (if their use is feasible) are the most efficient facility for displacing soil into the fill. The technical characteristics of conveyers is given in Table 12.

When the soil is moved through great distances, a main line is made up from a number of link conveyers, which, depending on local conditions, can be of different length. The soil can be dumped at the end of the conveyer, or at any point along its length (Fig. 37). In the fill [proper] the soil is moved by a dumping self-propelled conveyor.

TABLE 11

Марка автомобилей-самосвалов 1	2 Грузоподъемность, т	Вес автомобиля-самосвала без нагрузки, кг 3	Мощность двигател. л.с. 4	Габаритные размеры, мм 5			9 Объем платформ., м³	10 Размеры платформы, мм			Радиус поворота по колее наружного переднего колеса, м 11	Колея задних колес, мм 12	Тип разгрузки 13
				длина 6	ширина 7	высота 8		длина 6	ширина 7	высота 8			
КАЗ-600В 14	3,50	4525	93	5920	2380	2650	2,40	2480	2100	465	3,5	—	15 Боковая на обе стороны
ЗИЛ-585 16	3,50	4210	90	5940	2290	2130	2,40	2550	2060	500	8,0	1740	17 Назад
МАЗ-205 18	5,00-6,00	6765	110	6065	2640	2430	3,60	3000	2000	600	8,5	1920	»
ЯАЗ-210Е 19	10,00	12000	165	8190	2650	2725	8,00	4370	2430	800	12,0	1920	»
МАЗ-525 18	25,00	24380	300	8350	3220	3675	14,30	4700	2550	1200	10,4	2230	»

1) Dump truck brand; 2) freight capacity; 3) weight of dump truck without load, kg; 4) engine rating, HP; 5) overall dimensions, mm; 6) length; 7) width; 8) height; 9) platform volume, meters³; 10) platform dimensions, mm; 11) turning radius along the path of the external front wheel, mm; 12) path of rear wheels, mm; 13) type of unloading; 14) KAZ; 15) sidewise, from both sides; 16) ZIL; 17) from the rear; 18) MAZ; 19) YaAZ.

<u>Narrow gauge railroad transportation</u> is used advantageously for large and concentrated work volume under difficult conditions.

When soil is hauled into the fill by dump trucks, tractor drawn trailers and soil carrying carts, their movement is scheduled according to a loop scheme (Fig. 38), here the direction of motion should be opposite to that of the excavator movement, so as to eliminate the necessity of carrying the bucket over the cab.

TABLE 12.

Наименование показателей 1	2 Показатели по маркам транспортеров				
	Т-44 (лотковый) 3	Т-125	Т-80 (плоская лента) 4	Т-45	Т-126
Длина транспортера, м 5	5	5	10	15	15
Ширина ленты, мм 6	400	400	400	500	400
Скорость движения ленты, м/сек 7	1,6	0,8	0,8	1,2-2,5	1,0
Максимальная высота разгрузки, мм 8	710	1870	3700	5010	5700
Электродвигатель, квт 9	1,8	1,0	1,5	3,2	1,5—1,7
Вес, кг 10	450	220	352	1320	650
Производительность, м³/час 11	65	30	27	80	—

1) Designation of indicators; 2) indicators for conveyer brands; 3) (slat); 4) flat belt; 5) conveyer length, meters; 6) belt width, mm; 7) belt velocity, meters/sec; 8) maximal dumping height, mm; 9) electric motor, kw; 10) weight, kg; 11) productivity, meters³/hour.

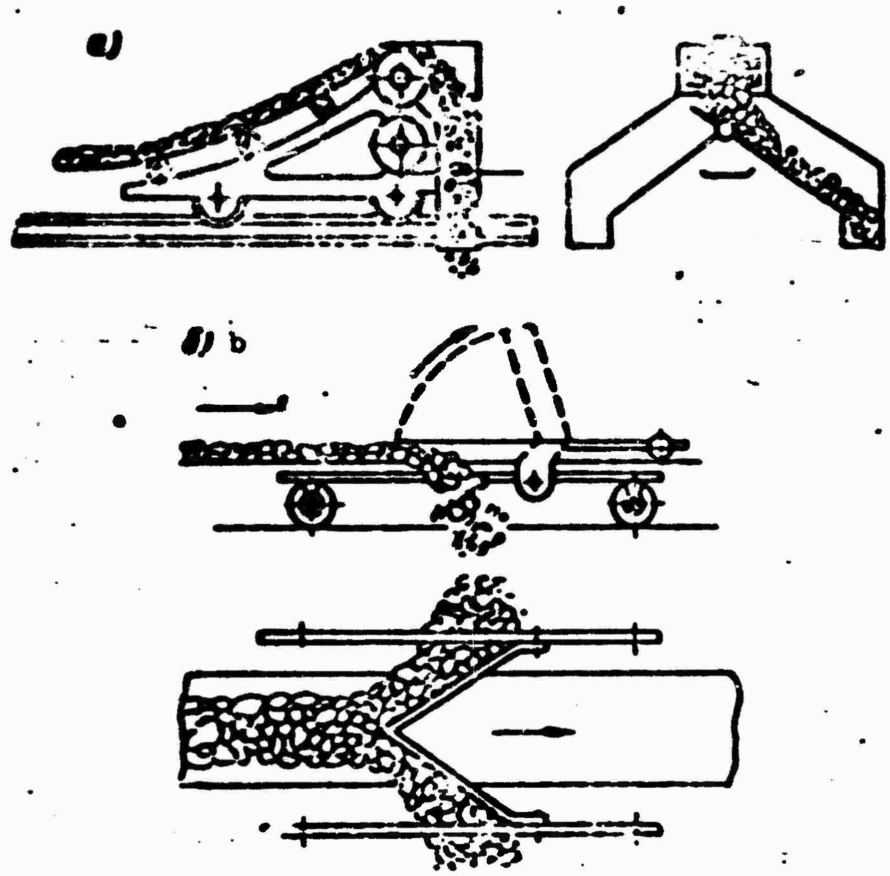


Fig. 37. Dumping devices for belt conveyors. a) Drum dumping device; b) plow-type two-side dumping device.

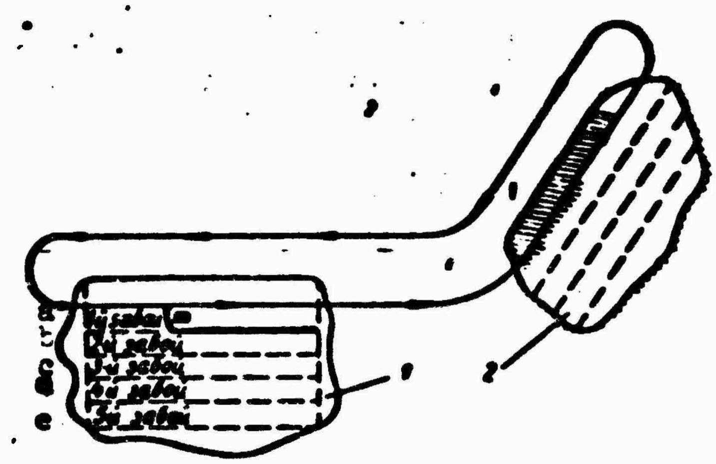


Fig. 38. Loop system for movement of transportation facilities in serving an excavator. a) 1st cut; b) 2nd cut; 3) 3rd cut; 4) 4th cut; 5) 5th cut.

The number of transportation facilities needed for hauling the excavated soil is calculated in the following sequence:

a) the duration of a complete cycle of one transportation unit is determined

$$T = t_1 + t_2 + t_3 + t_4 + t_5,$$

where t_1 is the time required for moving the transportation unit into loading position, minutes (0.5-1.5 min); t_2 is the loading time, min., equal, when the soil is loaded by an excavator, to:

$$t_2 = \frac{Q}{\Pi_e} c,$$

where Q is the body capacity, reduced to the case of solid soil, meters^3; Π_e is the loading productivity of the excavator, meters^3/min; c is a coefficient, taking into account time lost in accidental delays (assumed to be not more than 1.1); t_3 the time of loaded trip taking into account delays enroute, min;

$$t_3 = \left(\frac{l_1}{v_1} + \frac{l_2}{v_2} + \frac{l_3}{v_3} + \ldots\right) K_r,$$

where l_1, l_2, l_3 are lengths of individual sections of the route with different specific resistance to motion, meters; v_1, v_2, v_3 are the speeds at the different sections, meters/min; K_r is a coefficient, accounting for increasing the trip time due to slowing down in acceleration and braking (assumed to be from 1.0 to 1.2); t_4 is the unloading time and the time of delays in unloading (from 1 to 3 min); t_5 is the time of the return [unloaded] trip;

$$t_5 = \left(\frac{l_1}{v'_1} + \frac{l_2}{v'_2} + \frac{l_3}{v'_3} + \ldots\right) K_r,$$

where v'_1, v'_2, v'_3 are the speeds on the return trip over individual sections, meters/min;

b) the productivity of the transportation unit, meters^3/hour, is determined

$$\Pi_t = \frac{QK_n}{T},$$

where Q is the body volume (volume of the automotive train bodies), meters^3; K_n is a coefficient of nonuniform supply of transportation units for loading; T is the duration of the hauling cycle, hours;

c) the required number of transportation units needed to serve the excavator is determined

$$n = \frac{\Pi_{эк}}{\Pi_{т}},$$

where Π_{eks} is the operational productivity of the excavator, meters^3/ /hour.

Organizing Excavating Work

Excavating work is performed in accordance with the plan of earth moving operations. Their successful implementation requires that the section be first prepared.

The preparatory work consists in constructing roads, lightening of the pits and locations where the soil is filled, and also telephone or radio communications of the dispatch point with the cut and fill locations.

Excavator operations should be preceded by staking out operations, denoting the boundaries of cuts and fills. It is recommended that weekly and daily work schedules be compiled for sections of excavator operations.

Digging of soil by single bucket excavators consists of individual repeating cycles, including loading the soil, turning the bucket (lifting it also, if necessary) to the unloading point, unloading the bucket, reverse turn and lowering the bucket for loading the soil. The productivity of an excavator is found as a direct function of the duration of each of these operations.

The basic means for decreasing the working cycle of an excavator are decreasing the average turning angle for the excavator bucket in unloading and performing individual operations of the cycle at the same time.

The turning of the bucket takes up 50-60% of the total duration of

the cycle.

Platforms from individual mats, which are moved from place to place by the excavator should be provided when working in weak and moist soil.

As far as possible, it is expedient to move the excavator from pit to pit during day time.

Rocky soil which cannot be dug should be broken up by explosives. The width to which the soil should be broken up depends on the height of the slope, the length of the line of least resistance and the specific consumption of explosives, and should be determined by the plan of blasting operations. The rock pile thus formed is removed by the excavator in two passes.

Individual sections of remaining rocky soil are broken up by small blasts or by jack hammers.

16. FILLING AND COMPACTING OF SOIL

Requirements put to soil and the Procedure for Filling it

Independent of the method of operations and of the selected mechanization facilities, fills should be produced in conformance with certain rules, ensuring high quality.

The surface at which small fills are made should be cleared of stones, trees, stumps, brush wood, moss covering and sod. If this is provided for in the plan, before the fill is made the topsoil layer should be removed and piled onto windrows; here the storage locality should not interfere with moving the soil.

If the site has a transverse grade of more than 0.03, then, in order to provide for better binding between the base and the fill, the base surface is first loosened by a plow or cultivator in a direction perpendicular to the descent of the slope. For a slope of more than 0.2, steps, not less than 1.0 meter wide are made in the fill base.

Fills should be made only of soil which will make them stable. Preference should be given to gravel, sand and loam soils, which are a good base for pavements and are to the smallest extent subjected to deformations of all kinds. Muddy soils, which lose their carrying capacity in the moist state; wet clay, which is slow in drying; soil with a gypsum content of more than 5%; saline soils, which are very hygroscopic and moisture absorbing; frozen, ice-saturated clays, which deform extremely on thawing cannot be used for fills.

Soil in the majority of cases is not homogeneous and, consequently, has different properties. For this reason, each layer of the fill should be made of homogeneous soil. Soil with poor draining properties should be filled at the bottom part, and those with better draining properties should be filled in the upper part of the fill.

The soil is placed in the fill along its entire width in layers of uniform thickness. The surface of layers of soil with better draining properties is made horizontal, while the layers with poorer draining property soil are laid out at a slope from the center of the fill so as to drain the water. Soil placed into a fill should be graded and compacted before the shift is over (in order to prevent the soil from drying into loops or from absorbing moisture and being washed out by precipitation).

Fills are raised depending on the soil hauling method and on the method of its subsequent compacting. The surface of the filled layers should be made level and maintained in such a state which will make it impossible for water to accumulate or stagnate on it.

Scrapers or tractor-drawn trailers place the soil into a fill in parallel rows of specified thickness. The subsequent layer by layer compacting does not require great expenditures. Thus, on the average, one bulldozer or grader is required per each 200-300 meters^3 of filled

soil. Soil transported by dump trucks is unloaded in piles, for which reason leveling it is a more labor consuming operation (one bulldozer per each 80-100 meters^3 of filled soil).

When moved by conveyers, the soil is filled layer by layer in rows according to the fan scheme and is also leveled out by bulldozers.

When filling soil from railroad cars use is made of either sidings with shunt tracks or of loop sidings, depending on the dimensions and configuration of the fill. In order to avoid moving the unloading track over the entire width of the fill, the unloaded soil is moved out by bulldozers. In this case, the unloading track is simply raised after one or two layers have been filled.

In filling of deep gullies temporary overhead roads for the transportation facilities are sometimes constructed. The soil should be filled from the overhead roads always in layers, with [subsequent] leveling and compacting.

If the earth moving work is performed in accordance with a 2 year schedule, then they can be renewed in the spring only after complete thawing and drying of the filled soil to the optimal moisture content.

Nonconformance to the above rules for making fills will result in nonuniform settling which will result in deformation of expensive airport pavements.

Methods and Equipment used for Compacting the soil

The main goal of compacting the fills consists in producing such a soil state in the process of constructing the fill, which would eliminate subsequent settling.

Compacting increases the modulus of deformation of the soil and resistance to shear, the soil becomes more water resistant, the number of points of contact between soil particles increases and the porosity decreases.

The optimal density, determined by the con- uction site laboratory by the standard compacting method on the SoyuzdorNII instrument (instrument for standard compacting) serves as the indicator for determining the required density of soil depending on the importance of the structure.

The required soil density is determined depending on the optimal density and the optimal compacting coefficient using the formula $\delta_n = K\delta_{opt}$, where δ_n is the required density of soil in the fill, grams/ /cm^3; δ_{opt} is the optimal soil density, determined by the standard compacting method in the SotyzdorNII instrument and K is the optimal compacting coefficient.

TABLE 13

1 Грунт	2 Цементобетонные и асфальтобетонные покрытия		3 Щебеночные, обработанные битумом и цементо-грунтовые		4 Грунтовая часть летного поля	5 Полосы безопасности
	6 верхние слои грунта в зоне промерзания	7 слои грунта ниже зоны промерзания	6 верхние слои грунта в зоне промерзания	7 слои грунта ниже зоны промерзания		
	8 Требуемый коэффициент оптимального уплотнения					
9 Песчаный, песчано-гравийный, песчано-пылеватый, супесчаный, супесчаный мелкий . .	0,95—0,98	0,95	0,95	0,95	0,90	0,85
10 Пылеватый, пылеватый суглинистый, суглинистый, тяжелосуглинистый	0,95—1,00	0,95	0,98	0,95	0,95	0,85
11 Глинистый	1,00—1,02	0,98	0,98	0,95	0,93	0,85

1) Soil; 2) cement concrete and asphaltic concrete pavements; 3) macadam, bitumen coated and soil-cement; 4) unpaved part of the airfield; 5) safety strips; 6) upper soil layers in the frost zone; 7) soil layers below the frost zone; 8) required optimal compacting coefficient; 9) sand, sand-and-gravel, sand dust, sand loam, fine sand loam; 10) dusty, argillaceous dust, argillaceous, heavy argillaceous; 11) clay.

Values of optimal compacting coefficients are given in Table 13.

In the last few years the radioactive isotopes methods in being adapted for determining the physical characteristics of soil. The density of soil is measured by the phenomenon of dispersion of gamma-rays

in passing through the soil.

One of the major factors effecting the compacting of soil is its moisture content. A moisture content value at which maximal density is achieved in expending the same amount of mechanical work for compacting the soil exists for each kind of soil.

Approximate values of optimal moisture content for different types of soil are the following:

	Most frequently encountered values, %	Limits of extreme deviations, %
Sandy	8-12	7 and 13
Sandy loam	9-15	8 and 16
Dusty	16-22	12 and 24
Argillaceous	12-15	10 and 18
Heavy argillaceous	16-20	13 and 25
Dusty argillaceous	18-21	15 and 26
Clay	19-23	17 and 27

The optimal moisture, density and other soil indicators should be determined in the process of prospecting work, which will make it possible to classify the soils by their compactability and to choose the most expedient methods for compacting them.

Soils of the airfield are compacted by tamping machines, vibrator units or rollers. The compacting method is chosen taking into consideration the soil kind and moisture, the work volume and the method of making the fill.

Compacting the Soil by Rolling

When a sufficient area is subjected to compacting in a fill, use is made of tractor drawn smooth roll and sheepsfoot rollers. Smooth tractor drawn rollers are expedient when used for compacting noncohesive and low-cohesion soils. The thickness of a layer compacted by smooth roll rollers does not exceed 15-20 cm, for this reason, they are

used primarily in finish rolling, when it is necessary to obtain a level surface, on finish-rolling after or in working with sheepsfoot rollers.

The disadvantage of smooth tractor drawn rollers is nonuniform compacting of the filled soil layer and the possibility of formation of waves ahead of the rolls.

Sheepsfoot rollers are efficient in compacting cohesive soils, especially consisting of lumps. The projections ensure compacting at a slightly higher depth than the smooth roll. In compacting by light and medium sheepsfoot rollers the upper soil layer remains uncompacted by approximately 4-6 cm. For this reason it should be additionally compacted by smooth rollers.

Almost no wave formation is observed ahead of the sheepsfoot roller roll. It should be noted that it is inefficient to compact noncohesive and highly moist cohesive soils by sheepsfoot rollers.

The serially produced tractor drawn sheepsfoot rollers of the D-130B brand work with the DT-54 tractor, and 2-3 rollers, depending on the soil properties and moisture are drawn by a S-80 or S-100 tractor.

Technical indicators of smooth and sheepsfoot tractor drawn rollers are given in Table 14.

Cohesive soils can be compacted by self-propelled roll rollers weighing 8-10 and more tons. They are also used very successfully for compacting the bottoms of airport subpavement beds.

The D-302 and D-390 weight-dropping tractor drawn rollers are effective in compacting freshly filled cohesive soil. These rollers compact a soil layer up to 1.0-1.5 meters thick.

Weight-dropping rollers can be used for compacting not only filled but also naturally present soil with a broken structure. The advantage of the D-390 over the D-302A roller consists in the fact that in com-

TABLE 14

1 Наименование показателей	2 Показатели по маркам катков			
	3 гладкие	4 кулачковые		
	Д-126А	5 Д-130А	6 Д-220	7 Д-130Б
Вес катка без догрузки в рабочем состоянии, т 8	2,6	3,2	18,7(13,8)*	3,7
Вес катка с догрузкой балластом, т 9	4,4	5,0	28,3(31,4)*	5,5
10 Ширина уплотняемой полосы, м	1,3	1,3	2,73	1,34
11 Удельное давление на грунт, кг/пог. см:				
без балласта 12	20	37	40(30)*	42
с балластом 13	34	57	107(59)*	63
Высота кулачка, мм 14	—	175	400	183
Опорная поверхность кулачка, см² 15	—	22	66	20,8
Потребный тягач: 16	18	18	18	18
для работы с одним катком 17	ДТ-54	ДТ-54	ДТ-140	ДТ-54
то же, с двумя катками 19	С-80 20	С-80 20	—	С-80 20
Необходимое число проходов по одному следу на различных грунтах 21	6—10	6—12	4—8	6—12
22 Транспортная скорость, км/час	4	4	4	4
23 Производительность в смену, м²	2000	2700	8000	3900

*Numbers without parentheses are for 8 projection-carrying bands, number in parentheses are for 16 projection-carrying bands.

1) Designation of indicators; 2) indicators for roller brands; 3) smooth, D-126A; 4) sheepsfoot; 5) D-130A; 6) D; 7) D-130B; 8) weight of roller without additional load in the operating state, tons; weight of roller loaded by ballast, tons; 10) width of rolled strip, meters; 11) specific pressure on the soil, kg/cm of length:; 12) without ballast; 13) with ballast; 14) projection height, mm; 15) bearing surface of projection, cm^2; 16) required tractor:; 17) for working with one roller; 18) DT; 19) the same as above, with two rollers; 20) S; 21) required number of passes over the same trace on different soils; 22) road speed, kilometers/hour; 23) productivity per shift, meters^2.

pacting soil it moves in accordance with the shuttle scheme without losing time for turns.

Tractor drawn rollers on pneumatic tires are used for compacting of cohesive as well as noncohesive soil. These rollers come into ever-increasing use due to the fact that they compact soil to a great depth for a small number of passes.

Technical indicators of tractor drawn rollers on pneumatic tires are given in Table 15.

It should be pointed out that the D-219 and D-263 tractor drawn

TABLE 15

Наименование показателей 1	2 Показатели по маркам катков		
	3 Д-219	Д-263	Д-326
Тип катка 4	Одноосный с жесткой подвеской		Одноосный с независимой подвеской
Вес катка, кг: 7			
без балласта 8	1 900	5 000	13 000
с балластом 9	10 000	25 000	50 000
Ширина уплотняемой полосы за один проход, м 10	2,1	2,6	3,3
Толщина уплотняемого слоя, см 11	10—15	20—30	20—30
Удельное давление на грунт при полной загрузке балластом, кг/см² 12	6—8	13 Около 6	4
Число колес 14	8	6	5
Емкость кузова, м³ 15	5,25	11,5	24
Тяговые средства: 16			
для работы (трактор) 17	18 ДТ-54	19 С-80	18 ДТ-140
для транспортирования без балласта (автомобиль) 20	21 ГАЗ-51	22 ЗИЛ-150	МАЗ-200
Число проходов по одному следу 24	6—12	6—12	4—10
Производительность в смену, м³ 25	5000	4000	Около 4000 13

1) Designation of indicators; 2) indicators for roller brands; 3) D; 4) type of roller; 5) single axle with rigid suspension; 6) single-axle with independent suspension; 7) weight of roller, kg:; 8) without ballast; 9) with ballast; 10) width of strip rolled in a single pass, meters; 11) thickness of compacted layer, cm; 12) specific pressure on the soil when fully loaded with ballast, kg/cm^2; 13) about; 14) number of wheels; 15) body capacity, meters^3; 16) pulling facilities:; 17) for work (tractor); 18) DT; 19) S; 20) for transportation without balance (truck); 21) GAZ; 22) ZIL; 23) MAZ; 24) number of passes over the same trace; 25) productivity per shift, meters^3.

rollers are produced with a rigid wheel suspension, which brings about overloading of individual wheels and does not ensure uniform compacting of the fill. The D-326 roller has an independent wheel suspension, which eliminates the above shortcomings. A self-propelled roller on pneumatic tires (Fig. 39), which can be efficiently used for compacting of fills has now been assimilated.

Depending on the soil type, a corresponding compressed air pressure should be maintained in the tires of the roller wheels. For sandy soils, this pressure comprises approximately 2 kg/cm^2, and for sandy loam and argillaceous soils it is, correspondingly, 3-4 and 4-5 kg/cm^2.

The operational productivity of rollers is determined by the formula

$$П = \frac{vl(B - C)}{n} K_в \text{ meters}^2\text{/hour}$$

where v is the roller speed, meters/hour; B is the width of the roller coverage, meters; C is the overlap width (0.15-0.20 meters); K_v is the coefficient of roller time utilization.

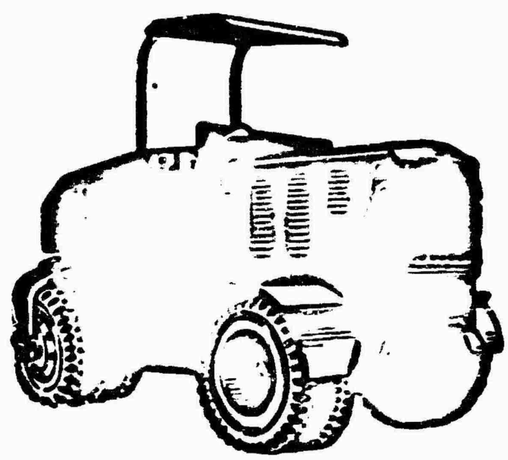


Fig. 39. The D-365 self-propelled roller.

The soil is compacted by longitudinal roller passes; the number of passes is determined depending on the type of soil and engineering requirements put to the fill. Depending on the area of operations and the type of tractor, units are made up of 1, 3, 5 and even 7 rollers. It is expedient to make up trains of smooth and sheepsfoot rollers, since this combination increases the degree of soil compaction, due to the fact that the smooth rollers finish foll (by compacting) the surface, loosened by the sheepsfoot roller.

The stresses at the soil surface due to the passing of the roller roll should not exceed the ultimate strength of the soil, if this is not the case, the compacting serves no purpose due to intensive formation of waves.

Loose soil is first compacted by light, and then by medium and heavy rollers. In the first pass the roller should move in the first gear 2-2.5 kilometers/hour), all the successive passes should be made in high gear and the last two passes again in the first gear.

The first pass at low speed ensures a more even soil surface, and the two last passes at low speeds bring the soil density to the optimal value and at the same time improve its structure. The recommended speed limit for the intermediate passes is 8-10 kilometers/hour.

Each filled layer should be compacted by the same number of passes by rollers of the same type.

The moisture of cohesive soils in their natural state is close to the optimal value, for which reason soil which is being filled should be compacted immediately, without allowing it to dry out in the hot and dry season or become overmoist in the rainy period. Excessive moisture makes it impossible to ensure the necessary moisture and strength of the fill.

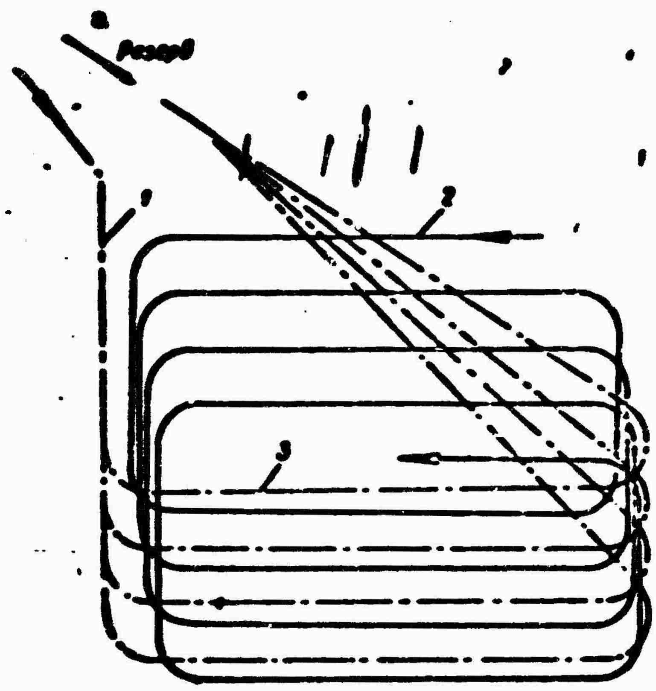


Fig. 40. Scheme of movement of tractor drawn rollers in compacting a fill. 1) Scraper train route; 2) roller route; 3) soil filling strip. a) Borrow pit.

The drying of overmoist soils should be accelerated by loosening their surface by plows or harrows. If not enough moisture is present (less than 80% of the optimal value) the soil is watered. It is sprinkled from the temporary water pipeline or by sprinkling machines, for example, the PM-8. The amount of water varies depending on the state of the soil and on the weather.

Tractor drawn and motor rollers should move in a straight line in the process of rolling, gradually moving from one edge of the fill to another. The basic scheme for the movement of tractor drawn rollers is shown in Fig. 40.

The dimensions of coverage are established depending on the roller

type. When rolling the soil using a train of three smooth tractor drawn rollers, the minimal coverage dimensions are 100 x 25 meters; for a heavy tractor drawn roller on pneumatic tires and for a sheepsfoot roller, they are 200 x 25 meters and for a motor roller they are 50 x 5 meters.

Compacting of Soil by Tamping

To compact soil by tamping, use is made of tampers, tamping plates serving as mounted equipment (Fig. 41), and special tamping machines. Tamping can be used for compacting cohesive, noncohesive and large rock bearing soils. Tamping plates may be made from steel weighing 2-3 tons and also made of reinforced concrete. The technical and operational indicators of crane-suspended plates are given in Table 16.

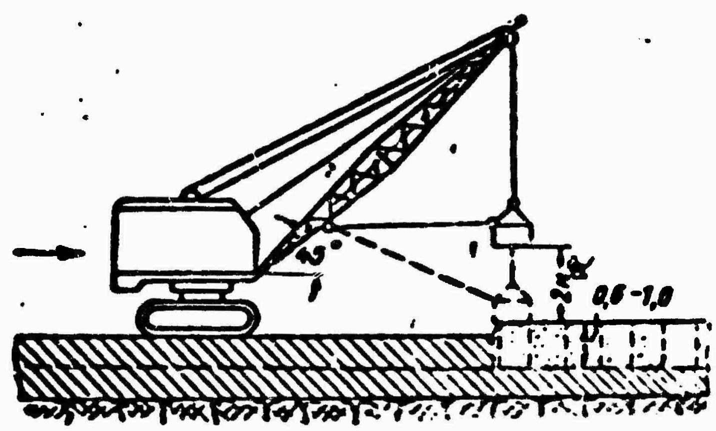


Fig. 41. Scheme of compacting fill soil by a tamping plate suspended from the boom of the E-505 excavator. a) 2 Meters.

It is recommended that the plate be dropped from a height between 1 and 3 meters, since at the instant of impact from a too large dropping height or in case of an overweight plate, the soil is displaced past the limits of the plate.

The productivity of tamping plates is determined by the formula

$$П = \frac{60 h_1 h (B - C)^2 K_в}{n} \text{ meters}^3/\text{hour}$$

where h_1 is the number of impacts per minute; h is the thickness of the compacted layer, meters; B is the plate width, meters; C is the overlap

TABLE 16

a	b			
	1	2	3	4
c	1,5	2,0	2,5	3,0
d	0,8x0,8	1,0x1,0	1,2x1,2	1,3x1,3
e	1—2	1—2	1—2	1—2
f				
g	25	15	15	15
h	17	8	8	8
i				
j	4—5	3—4	3	2—3
k	20	20	20	15
l	40—60	50—70	60—70	70—80
m	400—600	200—800	200—1000	300—1400

a) Designation of indicators; b) indicators for plate types; c) weight of plate, tons; d) dimensions of the plate in plane, meters; e) height to which raised, meters; f) number of impacts per minute; g) when raised to a height of 1 meter; h) when raised to a height of 2 meters; i) number of impact at a single point for compacting when dropped from the height of 1 meter; j) in sand loam soil; k) in clay soil; l) thickness of the tamped compacting layer, cm; m) productivity of plate per shift, meters^3.

width, meters; n is the number of impacts at the same point; K_v is the time utilization coefficient.

The fill soil is compacted in strips of 40 x 60 meters. From each stand the soil is tramped along an arc from the edge of the strip being compacted toward the middle. For greater compacting uniformity, the turning angle of the boom relative to the axis of excavator motion should be taken as not more than 45°. Each trace of a previously compacted strip should be overlapped by 0.10-0.15 meters. The number of plate impacts at a single point is determined experimentally with optimally moist soil.

Good results are obtained in compacting by a tamping plate dropped from rigid guides. This plate suspended from the E-505 excavator compacts by two impacts a soil layer of up to 1.5 meters.

Hammer-type tamping machines, whose working elements are hammers falling from a height of 20-30 cm are lately being adapted into use. These machines compact a soil layer of up to 70-80 cm.

Cohesive soils are expediently compacted by the S-325 soil compacting machine, installed on the basis of the E-505A crawler excavator, with a 1.0 meter compaction depth by 3-4 passes and with a productivity of 200-225 meters^2/hour.

Good results in compacting soil layers up to 1.0 meter are shown by the D-471 tamping machine with a compacting strip width of 2.3 meters. Here standard compaction of soil in a 1.0 meter layer requires 3-6 impacts at the same point.

The cost of compacting soil by the tamping plate is considerably higher than the cost of compacting by tractor drawn rollers, in conjunction with which the use of tamping is economically advantageous when the working area is constructed and when filling must be performed in deep layers.

Compacting the Soil by Vibration

The vibration method is used for compacting noncohesive loose soil to a depth of 1.5 meters and more. Gravel and crushed stone soils are compacted satisfactorily by vibration. Soil can be compacted by tractor drawn or self-powered vibrating machines, and also by vibrating machines suspended from the hook of a crane.

The self-propelled D-368V vibrating machine compacts a strip 1.2 meters wide. The working element of the machine is a cast steel plate to which a single roller controlled action adjustable vibrator is attached. A capstan which serves to shake the machine by means of a cable fastened to the ground anchor, when working under difficult conditions, is attached to the front part of the plate.

Technical characteristics of vibrating machines are given in Table 17.

A plate with vibrators mounted on it serves as the working compacting element of the vibrating machines (Fig. 42).

TABLE 17

Наименование показателей	Показатели по маркам машин	
	Д-369	Д-368
Тип машины	Прицепная к трактору с редуктором	Самоходная
Тип вибратора	С четырьмя расположенными дебалансами в двух корпусах, с вертикально направленной возмущающей силой	С тремя дебалансами на одном валу, с регулируемым направлением возмущающей силы
Тип и мощность двигателя, л.с.	ДТ-54, 54	Карбюраторный, четырехтактный, 32
Глубина уплотнения, м	1,0–1,5	0,5–0,7
Площадь опорной плиты, м²	1,8	1,4
Частота колебаний в минуту	750, 900 и 1100	800–900
Амплитуда опорной плиты, мм	15–20	4–7
Суммарная возмущающая сила, т	От 9 до 20	От 32 до 42
Вес вибрирующей части, кг	3000	1050
Рабочая скорость, м/час	190	300
Габаритные размеры, мм:		
длина	3780	2300
ширина	2340	1400
высота	1600	1330
Вес машины, кг	4800	1620
Производительность при одном проходе, м³/час	300	200

1) Designation of indicators; 2) indicators for machine brands; 3) D; 4) type of machine; 5) tractor drawn with a speed reducer; 6) self-propelled; 7) vibrator type; 8) with eccentrics placed in pairs in two housings, with a vertically directed exciting force; 9) with three eccentrics on a single shaft, with an exciting force whose direction can be adjusted; 10) type and rating of motor, HP; 11) DT; 12) carburator [spark ignition], four-cycle; 13) compacting depth, meters; 14) bearing plate area, meters^2; 15) frequency of vibrations per minute; 16) bearing plate amplitude, mm; 17) and; 18) total exciting force, tons; 19) from; 20) to; 21) weight of the vibrating part, kg; 22) working speed, meters/hour; 23) overall dimensions, mm; 24) length; 25) width; 26) height; 27) weight of machine, kg; 28) productivity per one pass, meters^3/hour.

The DM-89 vibrating roller, pulled by the DT-54 crawler tractor has given a good account of itself for layer by layer compacting of soil at an airfield. The vibrations created by the rotation of eccentric shafts of the vibrator are transmitted to the roll of the roller, which compacts a soil layer of 0.5-0.7 meters in 3-4 passes. The use of a tractor drawn vibrating roller is especially effective in compacting noncohesive and sandy soils.

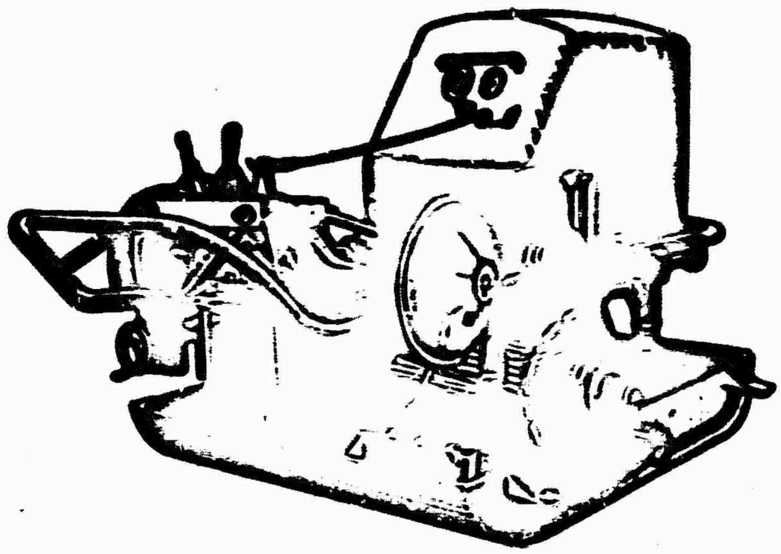


Fig. 42. General view of the D-368 self-powered vibrating machine.

Compacting of Fills by Transportation Facilities

Alongside with the basic methods for compacting c. fills it is also necessary to take into account and make maximal use of the compacting effect of earth moving and soil hauling facilities. By well thought over organization of the movement of earth moving machines, it is possible to achieve preliminary compacting of filled soil.

For example, when moving soil by scrapers the latter should be routed along a strictly specified direction calculated so that the scraper wheels and the tractor crawlers should uniformly cover the entire fill area. It was suggested, for improving the compacting quality, that the tractor drawn scraper should be equipped with several additional pneumatic tired wheels. The use of such a scraper-roller makes it possible to reduce their cost by approximately 20%.

17. GRADING OPERATIONS

Grading operations are performed in order to create a level airfield surface and to finish off the bottom of the airport subpavement bed.

The surface is leveled by a number of repeated grader passes over the same trace in mutually perpendicular directions with a pass over-

Наименование показателей	Показатели по маркам							
	грейдеры		автогрейдеры					
	Д-241	Д-265	Д-395	Д-420	Д-144	Д-446	Д-465 (Д-365)	В-10
Размеры отвала, м: длина	3,0	3,70	3,70	3,75	3,60	3,04	3,04	3,66
высота	0,30	0,50	0,70	0,55	0,55	0,50	0,50	0,50
Поворот отвала в плане, град. .	±55	±55	Полноповоротный				±62	Полноповоротный
Рабочие установки отвала: угол установки в плане к продольной оси, град. .	28—152	35—145	360	360	360 без кирковщика			360
угол резания ножей, град. .	30—60	25—70	35—80	32—66	30—85	29—66	30—75	57—105
наибольший угол перекоса отвала при выносе за габарит для зачистки откоса, град.	70	70	75—90	30—70	45—70	60	—	—
Глубина резания ножом, мм .	До 300	До 300	До 500	—	До 400	До 250	До 250	—
Наибольший вынос отвала в сторону (механизмов), мм	450	400	660	400—800	400	—	450	—
Дополнительное оборудование . .	Удлинитель	Удлинитель и откосник	Удлинитель	Удлинитель и кирковщик	Удлинитель, откосник и кирковщик	Удлинитель	Удлинитель, откосник и кирковщик	Удлинитель и откосник
Скорость движения вперед, км/час .	—		От 3,74 до 28,5	От 3,97 до 41,2	От 3,28 до 26,7	От 3,67 до 29,19	От 2,10 до 37,75	Максимальная 31,0
Скорость движения назад, км/час	—	—	От 4,10 до 5,77	От 2,08 до 4,08	От 3,37 до 6,56	От 4,65 до 13,82	От 3,18 до 16,9	—
Радиус поворота, м	—	—	17,0	17,2	17,25	10,6	12,0	12,75
База колес, м . .	4,40	5,30	5,98	5,70	5,80	4,67	5,15	5,45
Размер шин колес	—	—	16,00—24	14,00—20	14,00—20	12,00—20	12,00—20	12,00—20
Число колес . .	—	—	4	6	6	6	6	6
Тяговый трактор или мощность двигателя, л.с.	ДТ-54	С-80 (С-100)	150—225	110	93 (100)	54	54	54
Вес, кг	3000	4200	18 200	9000	13 130	8500	9470	10 200
Топливо	Дизельное							

1) Designation of indicators; 2) indicators for brands; 3) graders; 4) motor graders; 5) D; 6) D-20B; 6) D-20B; 7) V; 8) dimensions of the blade, meters; 9) length; 10) height; 11) blade rotation in the plane, degrees; 12) 360° rotation; 13) working positions of blade; 14) angle of positioning in the plane to the longitudinal axis, degrees; 15) without scarifier; 16) cutting angle of the knives, degrees; 17) greatest angle of inclination of blade when extended past the machine bulk for grading a slope, degrees; 18) depth of cut for the knives, mm; 19) up to; 20) greatest extension of the blade to the side (of mechanisms), mm; 21) additional equipment; 22) extension; 23) extension and banking tool; 24) extension and scarifier; 25) extension, banking tool and scarifier; 26) forward speed, kilometers/hour; 27) from; 28) to; 29) maximal; 30) reverse speed, kilometers/hour; 31) turning radius, meters; 32) wheel base, meters; 33) tire dimensions; 34) number of wheels; 35) pulling tractor or engine rating, HP; 36) DT; 37) S; 38) weight, kg; 39) fuel; 40) diesel.

lapping of 20-30 cm.

Earth moving operations involving correcting the microtopography of the airfield within the limits of ±10-12 cm (cuttong off of mounds, filling of depressions, small ditches, etc.), and finishing off of the surfaces of fills and cuts at the airfield and of the subpavement bed are included under the name of grading operations.

Motor and tractor drawn graders are mainly used for grading operations on the airfield. Rough preliminary grading can be performed by general purpose bulldozers. The subpavement bed, as a rule, is finished by motor graders. The technical characteristics of motor and tractor drawn graders are given in Table 18.

The operational productivity of a grader is determined by the formula

$$\Pi = \frac{3600L[(l + 2l_1)\sin\beta - C]K_v}{n\left(\frac{L}{v} - t_{pov}\right)},$$

where L is the coverage length, meters; l is the length of the grader knife, meters; l_1 is the length of the extension, meters; β is the coverage angle, degrees; C is the coverage size, meters; K_v is the time utilization coefficient; v is the speed, meters/sec; t_{pov} is the time spent in turning around the grader, sec; n is the number of passes over a single trace.

The methods for conducting grading operations depend on the requirements put to the surface and on the kind of airfield section at which they are performed.

The airfield surface is finished off after the earth-moving operations are finished and after the topsoil layer has been placed on the surface.

All grading operations are performed in two stages: first irregularities which can be seen by eye are removed and then the surface is

is finished off by a motor grader according to the leveling marks.

Grading of the Airfield Surface at Zero Sections

Topographical irregularities involving partial local moving of soil are corrected at the zero sections. Topsoil is not removed from zero sections. In category II and IV hard soil and also at sections previously occupied by trees or brushwood, the soil before grading is loosened by heavy rippers and then, if necessary, it is plowed. The soil should be loosened to a depth of not more than 10-15 cm, in order to avoid bringing mineral soil layers to the surface.

When performing grading operations by bulldozers, the blade is usually placed with the cutting edge just touching the surface. Moving forward, the bulldozer cuts off mounds and fills depressions, thus leveling the area. The grading accuracy in working with a bulldozer is not too high. In order to improve the grading quality, the bulldozer blade should be dragged over the surface with the bulldozer moving in reverse, due to which the soil is additionally leveled by the back face of the blade.

When the section has a well developed sod covering, it is preserved by correcting only individual areas whose microtopography does not satisfy the design data.

To ensure high grader productivity, the coverage length should be 300-350 meters and more, and the width for tractor drawn graders should not be less than 100 meters. Depending on the condition of the section, obtaining a level surface requires from 2 to 5 grader passes over the same trace.

The surface is graded by motor graders (graders) according to a loop scheme from the coverage boundaries to its middle or, conversely, from the middle to the boundaries. In making passes in mutually perpendicular directions the first and the last pass are made in the direc-

tion of the longitudinal axis of the unpaved airstrip. After the first motor grader (grader) passes, the graded surface is rolled to expose sections at which the soil density is insufficient. All the subsequent motor grader (grader) passes are alternated with rolling until a level surface corresponding to specifications is obtained.

The major factor on which the productivity and quality of the motor grader (grader) work depends is the angle of coverage of the blade (Fig. 43). The coverage angle is established depending on the soil type and on the surface condition in the limits between 35 and 60°. The smaller values of the coverage angle are used for difficult moist soil, and the larger values for light dry soils. If it is necessary to move soil in the direction of the grader motion, then the blade is set at a 90° coverage angle.

The cutting angle is established within the limits from 40 to 60° (smaller values for difficult soils, greater for light soils).

The angle between the blade and the horizontal (see Fig. 43) is set by the grader operator in the process of work in a manner which will ensure cutting off of individual surface irregularities. The maximal angle between the blade and the horizontal is $18\text{-}25^{\circ}$. The coverage and cutting angles can be increased for the last grader passes.

A considerable influence on increasing the pulling effort of the motor grader is exerted by the air pressure in the tires. Minimum values of the rolling drag coefficient will be obtained in working with loose soil, if the air pressure in the tires is 1.0-2.0 kg/cm^2, and in noncompacted soil when the tire air pressure will be 3.0-4.0 kg/cm^2. For this reason, the use of low pressure tires in combination with a centralized system for regulating the air pressure in them is most expedient, since it makes it possible to bring the air pressure in the tires in complete conformance with the operational conditions, which

increases the pulling quality of the motor grader and lowers the fuel consumption, which has been verified by the operation of the D-395 motor grader with low pressure tires.

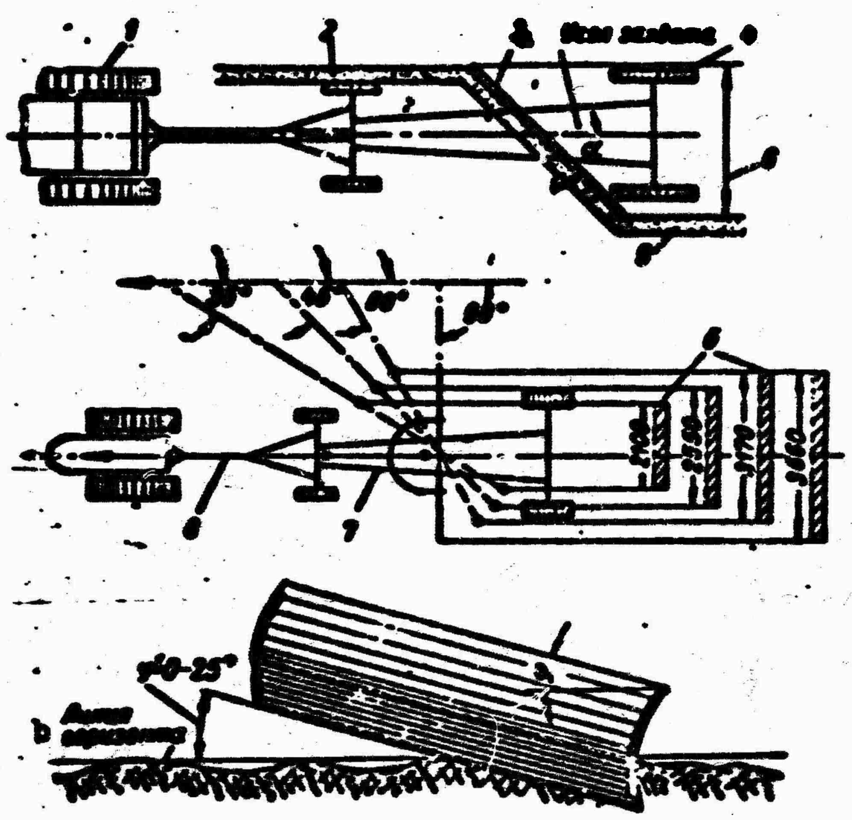


Fig. 43. Positioning angles for the grader blade. 1) Tractor; 2) front wheels; 3) blade with cutting edge; 4) rear wheels; 5) soil roll; 6) width of blade coverage; 7) base frame; 8) connecting gear. a) Coverage angle; b) horizontal.

When grading large areas by tractor drawn graders, it is recommended to use a unit consisting of two or three graders drawn by the S-80 or the S-100 tractor. Graders are fastened to the tractor by cables with a cross section of 20-25 mm and with a corresponding length of 11.77 or 27.77 meters.

Grading of cut and fill Surfaces

The surface of cuts and fills is graded after termination of basic earth moving operations. The allowable soil remainder in cuts is not more than 10-12 cm. To ensure high quality of operations, it is expedient to produce fills with a 6-7 cm surplus. The conformance of the obtained cut and fill surface to design specifications is checked by con-

trol leveling of the surface before commencing grading operations. If the soil left over at individual points of the cut exceeds 10-12 cm, then the soil should again be cut which should be immediately followed by grading. Depressions found in the fill should be filled before the start of grading.

The procedure for performing grading at cut sections and also the setting blade positions do not differ from that used at sections with zero elevations. Usually from 2 to 5 passes of grading machines over the same trace are necessary for obtaining a level surface. The number of passes depends on the precision with which the main earth-moving operations were performed, and also on the quality of the cut subsoil.

Thorough finishing of the cut is performed after the topsoil layer has been deposited on its surface.

The fill surface are finish graded only after careful compacting of the upper layer.

18. EARTH MOVING OPERATIONS UNDER WINTER CONDITIONS

Peculiarities of Operations in the Winter Time

Powerful earth digging equipment and experience acquired in the construction of airports and hydraulic structures make it possible to perform a certain part of earth moving operations in the fall and winter season.

Performance of earth moving operations in the winter time is complicated to a considerable degree due to frozen soil, low air temperatures and snow. All this in a number of cases results in increasing the cost of earth moving work in comparison with work during the summer season. However, taking into account the decrease in time required for work and the possibility of year-round utilization of equipment and earth-digging gear, the total cost of airport construction decreases, as a rule.

In palnning earth moving operations with respect to the times of the year, the climatic conditions of the construction region and the character of operations must be taken into account.

Work planned for the winter period should primarily be such which is performed simpler and cheaper precisely under winter conditions. These operations include removal of peat from marshes by excavators or by blasting, quarrying of cuts in quicksands by the freezing out method, etc. The working of rocky dry noncohesive soils and placing them in a fill does not entail large additional costs when performed in the winter time.

A considerable cost increase is involved when excavating cohesive overmoist soils in the winter time. The performance of small volume or scattered sections of earth moving operations, and also grading of the airfield surface is not advantageous in the winter time.

Work planned for the winter period primarily pertains to sections with concentrated soil masses and with short soil hauling distances.

Performance of earth moving work in the winter is economically advantageous when it is possible, in the process of operations, to maintain the soil in the pit in the thawed out state or when working with soil which has not frozen. Artificial thawing out of soil at the airfield is permitted only in exceptional cases.

A special plan of earth moving work is compiled for the winter, taking into account specific peculiarities of the given area. As a rule, earth moving operations in the winter should be performed throughout the day and night, especially when using scrapers and bulldozers.

The composition of earth moving operations performed in the winter time includes area clearing operations, loosening and windrowing of the frozen soil layer, and particularly earth moving operations with exposed not frozen soil layer.

Preparatory Work

Preparatory work and measures facilitating the performance of work in the winter should be performed in the fall, before the first frosts. They include staking out the contours of cuts and fills, including the restoration of the needed monuments, clearing the surfaces of cuts, fills and soil hauling roads, ensuring temporary water drainage; preparation of heating materials, fencing shields and devices for snow removal, preparing the earth digging equipment and gear for work under winter conditions, performing technical training in execution of work in the winter time and in safety precautions and construction of premises where the workers could warm themselves up.

Sections for which winter work is planned should be protected from freezing up or at least their freezing depth should be decreased.

When the excavation of a cut is slated for the beginning of the winter, the simplest method for protection of pits is plowing of the cut sections to a depth of not less than 0.35 meters with subsequent harrowing to the maximally possible depth. This decreases the thermal conductivity of the surface layer and, consequently, the amount of heat given up by the lower lying soil layers.

Soil can be protected from freezing by cross (double) loosening to a depth up to 0.50 meter by the tractor drawn D-162A cultivator (Fig. 44), which keeps the soil under the cultivated layer in the thawed state for the first third of the winter.

If earth moving work is performed throughout the winter, then the cut is protected from freezing by covering its surface by loose soil, snow or by local inexpensive insulating materials (dry peat, sawdust, slag, straw mats, etc.).

The most frequently used insulating material in snowbound regions is snow, especially, if the earth moving work is planned for the second

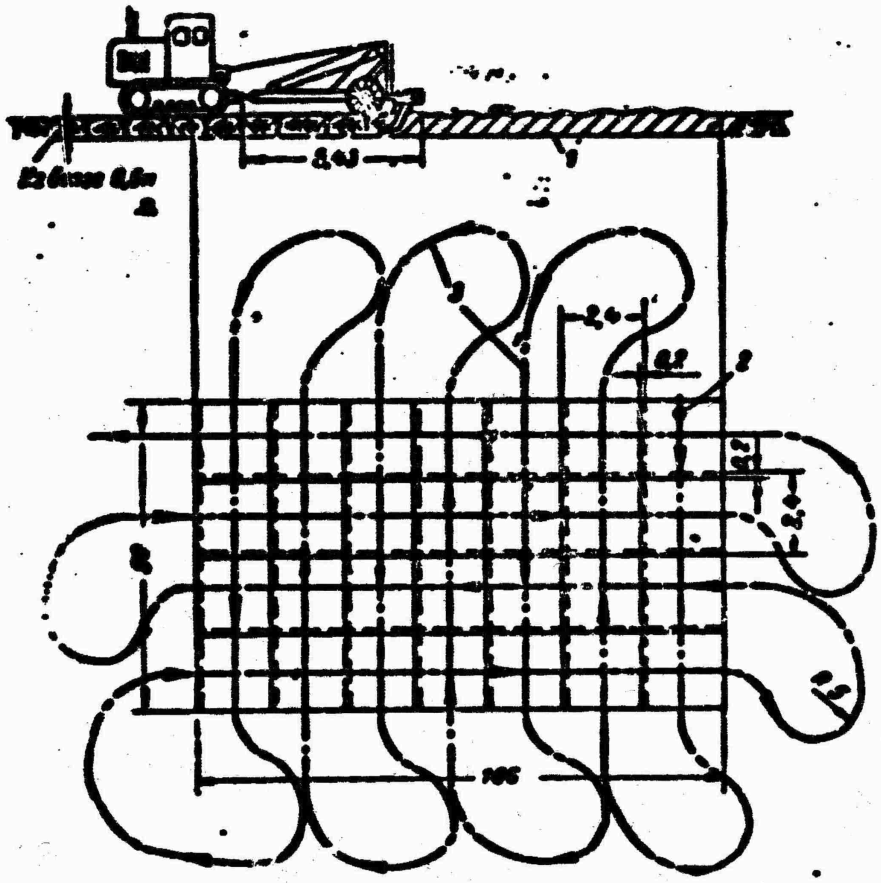


Fig. 44. Scheme for loosening of soil by the D-162A cultivator for protecting them from freezing. 1) Loosened layer; 2) point at which work begins; 3) axes of cultivator motion. a) Nor more than 0.5 meters.

half of winter. This method is the least expensive and at the same time effective, if we take into account that the time required for freezing even of dense snow is by a factor of 2 smaller than the freezing time of of unprotected argillaceous soil.

In regions where the snowfall is not profuse, it is expedient to accumulate snow by setting up shields and dets or by using snow windows placed in the path of winter winds.

Soil insulators are removed before the work at the given section begins.

Soil can be prevented from freezing, according to experience acquired by certain construction organizations, by introducing sodium chloride or calcium chloride into it.

Loosening and Windrowing of the Frozen Soil Layer

When the freezing depth is up to 20 cm, the frozen soil crust is

broken up by rippers, which depending on the character of operations make from 1 to 5 stands. The crust thus broken up is moved by bulldozers or scrapers out of the section. When the work volume is large, loosening is done by a special attachment in the form of a ball or wedge hammer, which is suspended from an excavator or crane boom. The above attachment can break up a frozen soil crust up to 40-50 cm thick. Loosening of soil frozen to 25-35 cm requires 2-3 hits by a 1 ton wedge hammer. When the freezing depth is large, a 2 ton wedge hammer is used. Good results are obtained by loosening with a diesel driven hammer, installed on a tractor or bulldozer.

Preliminary cutting of the frozen soil into blocks is used in addition to the enumerated methods. The dimensions of the blocks in the plane should correspond to the dimensions of the excavator bucket.

The cutting is performed by a special knife (Fig. 45), produced as replaceable excavator equipment, or by cutting disks fastened to a ditcher. Cutting of frozen soil into blocks requires 2-4 times less energy in comparison with thorough loosening.

Frozen soil is loosened by blasting using standard blast drilling methods. Blast holes are bored by pneumatic perforators or electric drills to a depth of 0.80-0.90 of the frozen layer thickness. The blast holes are staggered so that the distance between the blast holes exceeds to the freezing depth by a factor of 1.3 (Fig. 46).

Frozen soil is blasted by ammonites and ammonales, bolyl and picric acid. The use of dynamite under winter conditions is not permitted. The frozen soil lumps after blasting should be not more than 0.4 of the excavator bucket capacity, for a shovel equipped excavator, and 0.25 of the excavator bucket capacity for a dragline equipped excavator. After the blasting the frozen soil is removed and the holes are evened out by bulldozers. It is recommended that at temperatures above -20^{o}, blasting

be performed once every 24 hours, and at temperatures below -20°, it should be performed at each shift.

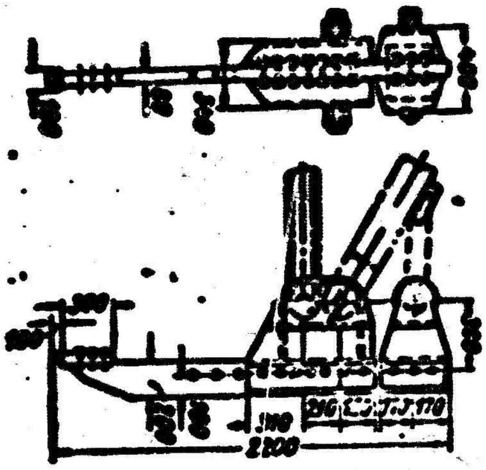


Fig. 45. Knife for cutting of frozen soil.

Quarrying of Cuts by Excavators

It is expedient to use excavators when working in deep pits, in order that the specific volume of frozen soil in comparison with the thawed out soil be as far as possible insignificant. When the frozen soil thickness is small (up to 25-30 cm), no additional loosening is required when using a power shovel [excavator]. When the frozen soil is up to 40-50 cm thick, it is loosened by a wedge or ball hammer, and the thawed out soil is excavated by a power shovel.

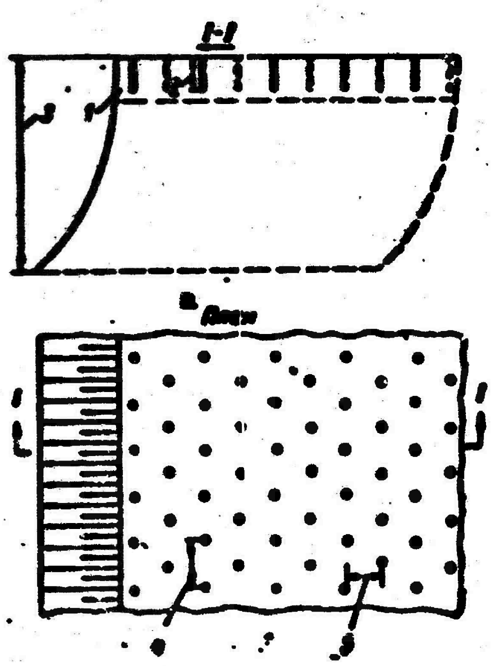


Fig. 46. Scheme for placing blasting holes and boreholes when loosening frozen soil. 1) Frozen soil; 2) depth of blasting hole and borehole; 3) height to which the bank is excavated; 4) distance between the blastholes and boreholes within a row; 5) distance between rows of blastholes and boreholes. a) Plan.

The wedge hammer can be operated from the same excavator which makes the cut. A type E-505A excavator ordinarily spends only 1.5 hours per shift for loosening of the frozen soil. Here it takes 30-40 minutes to replace the excavator bucket by the wedge hammer. When loosening frozen soil by blasting, the operations are performed at three coverage sections (Fig. 47).

The size of coverage sections is established depending on the excavator productivity per shift. During firing, the excavator is placed in a safe zone.

The excavation under winter conditions of dry sandy soil does not differ, by the working conditions, from those prevailing in the summer.

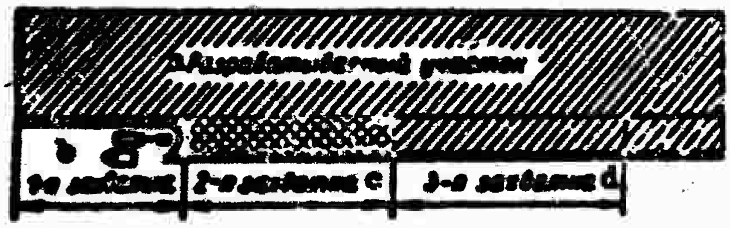


Fig. 47. Scheme for breaking up a section quarried by an excavator when loosening the frozen layer by blasting. The first coverage sections is the quarrying of the loosened soil; the 2nd coverage section is the loosened section; the 3rd coverage section is boring, charging the blastholes and firing the charges. a) Section under cut; b) 1st coverage section; c) 2nd coverage section; d) 3rd coverage section.

In working in clay soil and also in dusty overmoist sand soil, the number of excavating cycles is decreased by almost a half in comparison with summer work. The excavator bucket must be periodically cleaned of frozen soil sticking to its walls by pneumatic hammers or by electric heaters.

In the winter, it is necessary to have spare sets of excavator buckets.

The soil is moved into the fill primarily by dump trucks which should move with the highest possible speed. In order to prevent the soil from freezing to the body, the bottom is sprayed by slag or salt, and sprinkled with diesel oil when it is extremely cold. At the end of a shift, and before the lunch break, the body must be cleaned of soil frozen to it. The soil hauling time is scheduled so that the soil should not have enough time to freeze before unloading.

Quarrying of cuts Under Winter Conditions by Scrapers and Bulldozers

Cutting by scrapers and bulldozers should be conducted continuously over the entire area of the cut using a large number of machines, so as to prevent the formation of frozen soil pockets. The pit area should be minimal. At an air temperature up to -20° soil should be cut at the

same point not less than each 15 minutes, in order to prevent freezing over of open cuts before the entire cutting operation is over. A frozen soil crust must be loosened as soon as it is formed (for example, by using loosening teeth mounted on the bulldozer). After one coverage section has been quarried, the entire scraper (or bulldozer) team moves over to a previously prepared coverage section.

The scraper bucket bottom and the bulldozer blade are lubricated by spent lubricants or diesel oil before the start of work.

Organization of night work is of great significance for speeding up the winter earth moving operations.

Filling of fills in the Winter Period

In making fills in the winter time special attention must be paid to the quality of work. To ensure strength and stability of the fills, frozen soil, snow and ice should not be permitted to penetrate into the fill, and the open pits and soil placed in the fill should be protected from freezing as long as the filling work is in progress.

Directly before starting the filling operations, the fill base should be thoroughly cleared of snow, the surface ice should be broken up and removed from the fill area. The soil should be placed in the fill at a rate which will not permit the freshly placed soil layer to freeze before the next thawed layer is placed in the fill.

In the case of a forced interruption the filled soil layer is covered from the top by insulating facilities to prevent it from freezing. Subsequently, when recommencing work at this section of the fill, the ice, snow and also the insulating facilities are removed.

Placing of frozen soil, and also of soil with a moisture content close to the liquid limit in a fill is not permitted. The thawed soil lumps should be not larger than 15 cm in order to prevent extensive settling of the fill. Only soil with good drainage quality should be

placed in a fill.

The soil is placed in a fill in layers simultaneously over the entire width with thorough layer by layer compacting, which is most conveniently performed by rollers on pneumatic tires with independent wheel suspension.

If the earth moving operations plan calls for filling the lower part of the fill in the summer and of the upper in the winter, then draining soil is placed in the lower part or, at least a draining system is constructed between the summer and winter parts of the fill. Usually all the defects of a fill produced in the winter are exposed in the spring, for which reason a close watch should be kept in this season and deformation thus exposed, caused by settling of the fill, should be immediately correctly.

19. HYDROMECHANIZATION OF EARTH MOVING OPERATIONS

When earth is performed by the hydraulic method, the soil is excavated, transported and placed in the fill continuously using the energy of a water stream.

Hydromechanization in airport construction can be used in the excavation of deep cuts and in filling of high fills, for transporting concentrated soil volumes, excavated at the airfield by earth digging machines when constructing airports in food plains and river valleys and in constructing bankside sections of seaplane airports. Operations for excavating and enriching of sand and gravel are also performed by the hydraulic method.

The basic advantages of hydromechanization consist in the moderate weight of equipment, the simplicity of it's assembly, the low operational cost and high productivity.

In order for the hydraulic method to be effective, it should be used with large and concentrated volumes of soil at a moderate distance

from the cut to the fill locations; closeby large quantity water sources, ensuring performance of work; cheap sources of electrical power; favorable topographical conditions; ease in washing out of soil slated for excavation and removal.

Not all soils are washed out by water with the same ease. The ease of erosion depends on the cohesiveness and density of the soil. The more dense the soil and the greater the internal binding forces, the more difficult it is to wash it out. For this reason, noncohesive sandy loam and sandy soils are eroded easier and require a smaller water consumption than clay and argillaceous soils. Soil containing large fractions (gravel soil), are eroded easily, but they should be transported at high speeds so as to prevent the gravel particles from settling enroute.

Soils with good filtering qualities are used in the majority of cases for hydraulic filling, since soil from which water separates with difficulty dry very slowly and, consequently, fills made from these soils will dry for a long period of time (up to 2 years and more).

Hydromechanization of earth moving operations consists in the following processes:

washing out the soil and converting it into a slurry;

transporting the slurry to the hydraulic filling location;

hydraulic filling of the soil.

Of great significance are proper organization and mechanization of auxiliary operations, which includes preparing the surface, laying of water and slurry pipelines, construction of overhead lines; etc.

Excavating the Soil

Two methods of hydraulic excavation are available:

1. Washing out of soil in a dry pit by a pressure stream of water using hydraulic excavators.

2. Drawing in of soil together with the water from the reservoir bottom, using a suction dredge.

A stream flowing out from the hydraulic excavator nozzle is directed at high speed to the excavated point of the pit and washes out soil which flows along a ditch or slope to the slurry intake of the suction dredge or to the head of the trough (in free flow transportation).

Hydraulic excavators are made with a central bolt, with a spherical hinge GMN, GM2 and others. The basic indicators of hydraulic excavators are the water productivity, speed of the stream on issuance and the pressure ahead of the nozzle.

The water consumption of a hydraulic excavator is determined by the formula

$$Q = v\frac{\pi D^2}{4}\varphi \text{ meters}^3\text{/sec}$$

where v is the nozzle velocity of the stream, meters/sec; D is the diameter of the exit hole, meters and φ is the flow coefficient (velocity coefficient), approximately equal to 0.93-0.96.

The required nozzle diameter is determined from the same formula if the water flow rate is given.

The value of the destroying velocity comprises: for sand 10-15 meters/sec, for sandy loam 18-27 meters/sec, for argillaceous soil 18-26 meters/sec and for clay 25-34 meters/sec.

The nozzle velocity of the stream should exceed the destructive velocity of the stream, the value of which depends on the soil [type].

The hydraulic excavator is supplied with water by centrifugal pumps with a delivery from 300 to 1600 meters^3/hour.

The required pump delivery is determined by the formula

$$Q = \frac{Vq}{T} \text{ meters}^3\text{/hour}$$

where V is the total volume of soil to be washed out, meters^3, q is the

specific flow rate of water needed for excavating 1 $meter^3$ of soil, $meters^3$ and T is the number of hours during which the work should be performed.

The rating of the drive for the pump supply the hydraulic excavator with water is calculated by the following formula

$$N = \frac{QH_n}{367\eta}\ \text{kw}$$

where H_n is the head created by the pump, meters; and η is the pump efficiency (0.7-0.8).

The head produced by the pump should be greater than the available head at the hydraulic excavator nozzle by the amount of pressure losses in the hydraulic excavator proper and by the topographical difference between the elevation of the hydraulic excavator and of the water intake level. The water is supplied from the pumping station to the hydraulic excavator along steel pipes with flange joints. Pipes are protected from rusting by covering them by a special compound.

The pipeline route should be chosen by taking into account the topography of the area, in order to minimize the capital and operational expenditures.

The pipelines are tested at a pressure not less than 150% of the working pressure. An act must be compiled listing the test results.

Most frequently the soil is eroded from the bottom by a head-on stream, locating the hydraulic excavator at the base of the pit (Fig. 48).

The stream directed at the base of the pit washes out the soil, causing the upper layers to cave in, which ensures high productivity. The stream should be directed almost perpendicular to the pit wall. The hydraulicing operation should be continuous, slowly moving the water stream from side to side. The productivity of the hydraulic excavator

depends to a large extent on the distance at which it is placed from the pit base. As the distance increases, the force of the impact of the water stream on the pit walls decreases. But due to the danger of possible caveins, the allowable distance between the excavator and the pit wall is the height of the pit. For placing the hydraulic excavator stream at the smallest distance from the pit wall, use is made of special close-quarter operation hydraulic excavators (armored GBB [close quarter operation hydraulic excavator]), all the mechanisms of which are covered by an armored dome, and the control is achieved by electric motors from the excavator control point.

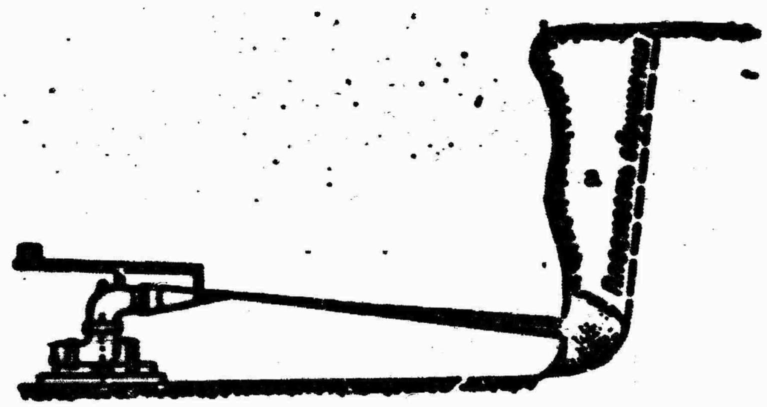


Fig. 48. Scheme for hydraulicking by a hydraulic excavator (from the bottom up) by a direct stream. a) Cave-in plane.

When hydraulicking a cut "from the top" (by back cutting), the hydraulic excavator is placed above the pit being excavated. However, this method is not as productive and is used less frequently.

The time after which the hydraulic excavator is moved to a new position is called the hydraulic excavator pitch. An attempt should be made in hydraulicking that the number of moves from the old to the new position should be as small as possible.

It is known that the erosion intensity increases by increasing the water flow rate from the nozzle, for which reason it is always advantageous to perform hydraulicking operations by one large hydraulic excavator than by two moderately sized, with the same total water flow

rate.

The excavating effectiveness is increased by combining the hydraulicking with preliminary loosening of the soil by a bulldozer. Then the specific consumptionof electric power is lowered to 30%.

If the section is made up of difficult soil, then it can be quarried by excavators or bulldozers, moving it into special installations where the soil is made into a slurry which is then supplied to the hydraulic fill point by a suction dredge.

Floating hydraulic dredges are used for excavating underwater soil when constructing airports in flood plains and river valleys. The floating dredge sucks in a slurry and creates a pressure for moving it to the pressure slurry pipeline to the point of hydraulic fill. In addition to floating hydraulic dredges, use is made of land bound hydraulic dredges, either stepping or on slide rails.

Transporting the Slurry

The soil washed out by hydraulic excavators flows freely through open ditches or receiver troughs to a collector and then it is supplied by a hydraulic dredge at a pressure for transportation to the fill. If natural slopes are available and the distance to the fill section is insignificant, the slurry is moved by free flow along main troughs.

Due to the fact that they have to be moved frequently, the receiver troughs are made from short links up to 3-4 meters long. The main-line troughs, as a rule, are not moved over, or are moved over very infrequently, for which reason they are made by using the entire length of the boards. The boards are connected with groove and tongue joints and the gaps are calked.

Main line troughs and slurry pipelines, as was shown by experience acquired in their use, should be laid on overhead ramps with a height from 0.5 to 1.0 meters and more.

If, due to topographical conditions, the slurry cannot move by free flow, then it is moved over by soil pumps, the operating principle of which does not differ from that of ordinary centrifugal pumps. The soil pumps are produced with deliveries from 30 to 1000 meters^3/hour with an available head from 20 to 80 meters.

In calculating the head which should be produced by the soil pump, it is necessary to take into account the specific weight of the slurry, which differs from the specific weight of water, and the slightly increased resistance to the motion of the slurry. Speeds needed for transporting of slurry in pipelines and by free flow in troughs are given in Table 19.

TABLE 19

Размываемый грунт 1	Скорости, необходимые для транспортирования пульпы, м/сек 2	
	самотеком по лоткам 3	под напором по трубам 4
Ил, глина 5	0,2	1–1,5
Песок мелкий 6	0,4	2–3
Песок крупный 7	0,8	3–4
Гравий мелкий 8	1,5	4–6
Галька окатанная размером 2,5 см 9	2,5	4–6

1) Soil being washed out; 2) speeds needed for transporting the slurry, meters//sec; 3) by free flow in troughs; 4) under pressure through pipes; 5) silt, clay; 6) fine sand; 7) coarse sand; 8) fine gravel; 9) drenched pebbles, 2.5 cm in size.

The pulp from the receiver is pumped by the soil pump into the slurry pipeline consisting of large diameter pipes. Welded thinwalled steel pipes are usually used for the slurry pipelines. The costs of constructing pipelines constitute the main expenditures for auxiliary hydraulic structures, for which reason, proper choice of the route and a well planned organization of installation are of great significance in decreasing the cost of hydromechanization.

Sharp pipeline turns should be avoided in routing, since this results in increased wear of the slurry pipeline turning points. When the pipelines are laid out with steep angles and large slopes, they can be stopped up when the soil pump is disconnected.

In order to save pipes, the slurry pipeline routes are laid out as

far as possible along a straight line, frequently over difficult terrain. For this reason, the pipes are distributed along the route by crawler tractors with trailers. It is expedient to use a light tractor in order to more completely utilize its capacity. The tractor trailer can be on wheels or on runners.

It is recommended that pipes be laid out on the ramp and assembled by the BE-2 pipelaying crane or by an excavator crane with a 3-5 ton capacity with a boom 8-12 meters in height.

During the assembly work the pipe layer moves parallel to the route, raising the pipes to the required height and moving together with the pipe, if necessary, along the route.

Due to the poor passability under roadless conditions characteristic of the construction site, truck mounted cranes are not used for assembly of pipelines, but they can be used to an advantage in loading and unloading of pipes in warehouses and in removing them from railroad flatcars.

Main line slurry pipelines are assembled in the following sequence: first the ramp, which maintains the pipeline on a uniform level is constructed, and then pipes are delivered along the route and deposited near the ramp.

Inaccuracies discovered in leveling the ramp surfaces are corrected by placing inserts at support points which require them. The height of the inserts should not exceed 6-7 cm. The pipeline fittings should be installed together with the pipes.

The pipes should be assembled starting with the end of the pipeline, with points of intersection with roads or with fancy parts.

Before putting it into service, the pipeline and its installations are subjected to a hydraulic test.

Hydraulic Filling

The use of hydraulicking in filling of fills at the airfield is expedient in the case of large areas and volume of work (Fig. 49).

Hydraulic filling can be performed by the ramp or rampless method.

In the ramp method, the hydraulicking slurry pipelines are laid out on wooden or metal ramps, which are moved over as a layer of specified thickness is filled. Dismountable ramps made from metal are more convenient due to the fact that they can be reused and due to complete mechanization of the erection work.

The slurry is expelled from the hydraulic fill pipelines through the ends of the pipes or through a row of intermediate holes equipped with slide valves. The holes are located at 3-6 meters from one another. The slurry is transported to the fill slope through wooden troughs with a cross section of 20 x 30 cm.

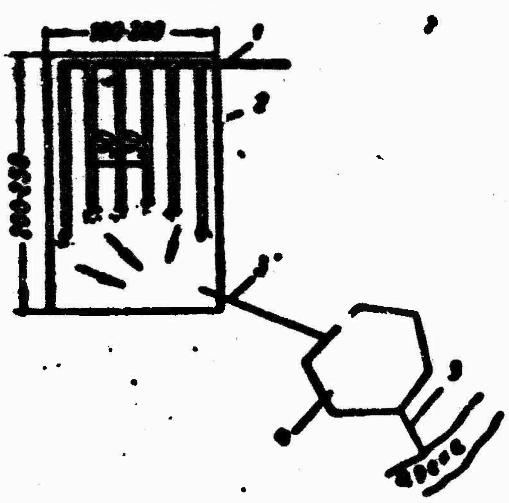


Fig. 49. Scheme of hydraulic filling. 1) Slurry pipeline; 2) shield fence; 3) collecting ditch; 4) natural settler. a) River.

The ramp method of hydraulic filling has a number of disadvantages which limits its use. They include the large volume of auxiliary work, forced interruption of hydraulic filling operations when the pulp pipelines are moved from place to place, and also the expenditure of a considerable amount of construction materials.

The rampless method of hydraulic filling, in which the slurry pipelines are laid out directly on the surface of the hydraulicked soil, eliminating thus the disadvantages characteristic of the ramp hydraulicking method, is more efficient.

In the rampless method, the slurry is spilled out directly from

the end of the pipe. After the specified soil layer has been pumped in, the pipeline is extended by a link and a new area is filled by the hydraulic method. The filling process continues in this sequence to the end.

It is very important that the hydraulic filling process should not be interrupted when adding a new pipe to the slurry pipeline. When the topography permits, the hydraulic filling should also continue in the opposite direction. For this purpose, the individual pipes are gradually dismantled, and the hydraulic filling is performed from the end of the still assembled pipe lying on the surface of the fill.

For joining convenience the pipes are equipped with rapid uncoupling joints. Small diameter pipes are most expediently attached by light portable electricity-driven cranes.

Windrowing at the hydraulic fill area is performed by bulldozers or by a special worm windrowing machine mounted on the S-80 tractor. In rampless hydraulic filling it is expedient to use an excavator with crane and clamshell working equipment with a 0.5 meters^3 bucket capacity.

Sections without water drainage are, prior to hydraulic filling, provided with ditches such as dug for a temporary drainage system, for subsequent draining of water from the body of the fill away from the airfield area back into the water reservoir or a settling basin.

If the soil is homogeneous, high fills are hydraulicked by the concentrated method, i.e., directly from the end of the slurry pipeline. When hydraulic filling simultaneously from several slurry pipelines, care should be taken that the fill produced by slurry pipelines laid out over the lowest part of the fill should not overtake the fill produced by other slurry pipelines, since in the opposite case quicksand sections may form, water removal from which is very difficult. Hydrau-

lic filling of nonhomogeneous soil is performed by the distributed method through distributing holes.

The soil of the hydraulically produced fill is characterized by its high density; the process of increasing the density in the hydraulically produced fill involves the removal from it of excessive water. Sandy soils give up moisture rapidly, and if proper drainage is provided, the process of compacting them is performed rapidly (here the soil density obtained is even greater than that in the natural state).

The water removal process in clay and dusty soils takes a long time (sometimes years), for which reason these soils should not be used when producing fills by the hydraulic method.

20. CONTROLLING THE QUALITY OF EXECUTION OF EARTH MOVING WORK

During the performance of earth moving operations, it is necessary to check the performance of main operations for removal and restoration of the topsoil layer, with respect to the excavation of cuts, clearing and compacting of fills and grading operations. Special attention should be paid to controlling the compacting quality, which is the major factor ensuring the stability of pavements and of the unpaved part of the airfield.

The quality of removal and windrowing of the topsoil is checked by inspection; here it is established whether the topsoil layer has been removed completely and whether it is stored properly. If admixtures of mineral soil, tree roots and other foreign bodies are found in the topsoil, the work for removing it should be stopped and the found shortcomings eliminated. The thickness of the created topsoil layer is checked by test diggings (5-10 diggings are made per 1 hectare). The deviation of the topsoil layer from the design specification should not exceed 10%.

The soil of cuts slated for placing in fills is inspected prior to

the commencement of earth moving operations.

The construction site laboratory determines the optimal moisture and the required density of the fill soil. The quality of soil in the base of pavements should be especially thoroughly checked.

In the process of filling the fill the soil density should be determined for each filled layer. Samples for determining the specific weight of the soil frame are taken from each 20 cm of depth of the filled and compacted layer.

The following samples are taken for determining the moisture content: for a layer thickness of up to 0.5 meters a sample is taken from its upper part; for a thickness of more than 0.5 meters an additional sample is also taken from the middle part. Samples for moisture determination are taken at the same time with samples for determining the specific weight of the soil frame. A subsequent soil layer cannot be filled without checking the degree of uniformity of compacting the preceding layer.

In filling of gulleys and holes, the quality of soil compacting is determined for each filled and compacted soil layer 10 cm in thickness. Samples are taken for each 20 meters^2 of a hole or ditch and for each 50 meters^2 of a gulley.

The basic indicators for the qualit. of the created airfield and subfoundation bed surfaces are their conformance to the design elevations and grades.

The elevations and grades are checked by control leveling passes along the existing points of the design leveling network. At earthmoving sections within the limits of the land area, the control leveling lines are laid out in two mutually perpendicular directions along points removed from one another by not more than 80 meters, and on the surface of the subpavement bed they are laid out along all points of the design

leveling network. The deviation of elevations of the created surface from the design elevations should not exceed ± 4 cm, and the deviation of grades of the subpavement bed for runways should not exceed ± 0.002, and for taxiways and aprons ± 0.003.

The general direction of slopes should conform to that established by the plan and should ensure free drainage of precipitation. The subpavement bed surface should not contain closed depressions in which water can accumulate. At the time of earth moving operations, rapid and complete removal of water should be ensured by using temporary water drainage ditches using elements of the [future] permanent drainage network.

The level of the airfield and subpavement beds is controlled by special sighting devices and surveying rods. In checking with a 3-meter surveying rod, the surface should not contain irregularities higher than 5 cm on the unpaved section and more than 3 cm on the subpavement bed bottom.

The position of the axis and subpavement bed is checked by a theodolite, here the permissible deviations from the specifications should not exceed 15 cm. The width and length of the bed is checked with a metal measuring band. The permissible linear deviations from design specifications are 1:1000 for the width and 1:2000 for the length.

A graded bed may not be left alone for longer than one day.

Earth moving operations at intermediate stages are received at individual sections after all earth moving operations have been finished, including the restoration of the topsoil layer.

The following operations should be verified in the process of performance of the earth moving work with the participation of the quality control representative of the airport operating authority: removal of low-quality soil and their replacement by stable soils; compacting of

each layer of the fill; removal of topsoil; restoration of topsoil; preparation of the fill site (loosening, removal of sod, etc.); construction of the subpavement bed.

Verification with mandatory participation of the representative of the airport operating authority is also performed in the execution of additional earth moving operations not provided for in the plan, for example, when changing the soil hauling distance, correcting of damage resulting from thawing or rain water, etc.

Intermediate acceptance of earth moving operations is performed by their types, given in unit cost sheets, once monthly. The delivery is formalized by an act according to the established form.

In accepting, a check is made of the grades, surface level, degree and uniformity of soil compaction, and also of the thickness of the topsoil layer. The degree and uniformity of soil compaction is checked by the specific weight of the soil frame not less than in one-two points per each 2000-2500 meters^2 of the area of the airfield layer and each 1000 meters^2 in the subpavement bed.

At fill section more than 1 meter high one sample is taken at the fill surface and another at a depth of 1 meter. At fills up to 1 meter in height, the second sample is taken from the lowest fill layer.

The thickness and uniformity of the topsoil layer is checked by measuring in test digging holes constructed in quantities of not less than 5 per each 1000 meters^2 of the earth moving operation area, uniformly over the entire area.

The acceptance acts should be supplemented by journals of control leveling and measurements, journals of all tests of soil density performed in the process of performance of the operations and also by journals of control tests of soil density.

21. SAFETY MEASURES IN PERFORMING EARTH MOVING OPERATIONS

The variety of earth moving operations and conditions under which they are performed requires special safety measures.

Earth moving operations at the present time are completely mechanized, for which reason the safety measures reduce to proper operation of the airport construction machines and to measures for preventing cave-ins and slippages of soil. Earth moving operations should be implemented in accordance with a previously established operational plan, which provides for safe methods of their execution.

Earth digging machinery may be operated only by persons which have been licensed to operate the corresponding machines and which have been instructed in safety measures.

At the time the machines work all dangerous places should display signs and warnings at visible points.

The earth digging machines should be equipped with sound signalization well known to all workers in the pit. A table with the signals is hung at a visible point on all earth digging machines. When working with drawn equipment, the commencement of the tractor's motion, its stopping and changing of its motion should be signaled to the worker riding on the drawn machine.

Standing between the drawn machine and the pulling tractor, walking over the towing device and standing on the frame, axles and wings of the tractor when the drawn machines are in motion, is prohibited.

The presence of outside persons on operating earth digging machines is not permitted.

The routes used by earth digging machines and truck approach roads should be always maintained in a state ensuring safety, preventing accidents, providing for convenience in operation and high productivity of equipment.

Lubrication, adjustment or any repairs and also mounting or dismounting from machines in motion is prohibited. It is not permitted to leave a machine with the engine working.

When fueling, smoking is prohibited within a radius of 15 meters. After fueling, the tank should be wiped dry. The storage of gasoline, kerosene and other highly inflammable substances in the cab of the machine is prohibited.

Operators and workers on drawn machines should be dressed in working clothes and should wear glasses to protect their eyes from dust.

When working during the night, the object, machines, transportation facilities and approach roads should be well illuminated.

When using scrapers in earth moving operations, the direction of movement of loaded and empty scrapers should be established and measures should be taken to provide for safety under the given work conditions.

The distance between tractor drawn scrapers working simultaneously should be not less than 20 meters. A scraper is permitted to work at sections with a longitudinal grade of not more than 10° and with a transverse grade of not more than 18°.

After its work is finished, the scraper should be cleared of roots and stems.

When bulldozer operations are performed, it is forbidden to stand in the space between the tractor and the blade, before their coming to a full stop. When the bulldozer stops, the blade should be lowered to the ground.

When working on an ascending slope, care should be taken that the blade does not dig into the soil. Work should not be done on ascending slopes of more than $25\text{-}30^{\circ}$ and on descending slopes of more than 35°. In order to prevent slipping down when dumping soil down a slope, it is

forbidden to move out the bulldozer blade outside the edge of the slope.

The winch cable should not be guided by hand when winding it on the drum. The winch should not be touched during operation. Cables may be in-stalled only when wearing gloves.

The bulldozer should be moved with the winch shut off and with the blade raised over the surface by not less than 0.35 meters, and a bulldozer with a hydraulic drive should move with the pump shut off.

In performing grading operations, the grader operator should constantly hold the steering wheel and the control levers. The grader is turned around at the end of a section in first gear. At the time the grader moves it is categorically forbidden to remove roots and stones from under the knife, and also to sit on the axles and frame of the machine.

If earth is moved by blasting, then the Uniform Safety Rules in the performance of blasting operations must be followed.

Chapter 3

CONSTRUCTION OF THE WATER DRAINAGE NETWORK

22. GENERAL INFORMATION

The water drainage network serves for collecting and draining away surface and ground water from the pavements and the flying field from the limits of the airfield. The drainage system ensures stability of the soil and pavements of the flying field and also creates normal conditions for the development of sod-producing grass.

The construction of the drainage network elements (Fig. 50) and its location in the plan are determined by the airfield design plan depending on local conditions.

The most characteristic and frequently encountered kind of dewatering operations is the construction of water drainage lines, ensuring the interception and drainage of surface or ground water from pavements; in conjunction with this, these operations are considered in more detail.

The construction of the drainage network includes: preparatory work, opening of trenches, ditches, bracing them, discharging and lowering the level of water, construction of hydraulic installations on the drainage network, constructing pipeline foundations, laying of pipes and sealing of joints, checking the watertightness of pipes and joints, backfilling the trenches, constructing water-discharge wells, drains and other operations.

In the process of constructing the drainage network, daily checks must be made of all kinds of operations. In addition to the daily

checks, all finished elements or sections of the network to be covered over by subsequent operations should be inspected and accepted by the quality control representatives of the ordering organization, which includes drawing up of acts for work subsequently covered over according to the typical form.

Succeeding operations may be performed only after the preceding covered over elements were accepted, the quality of the materials used checked and shortcomings eliminated, since the stability, strength and long service life of the entire drainage system and the time it will be in operation depends on the quality of the work which is performed.

23. PREPARATORY OPERATIONS

Preparatory operations in the construction of the drainage network consist in marking out the network, clearing its route, staking operations, constructing a temporary drainage system, accepting and distributing pipes and materials along the route.

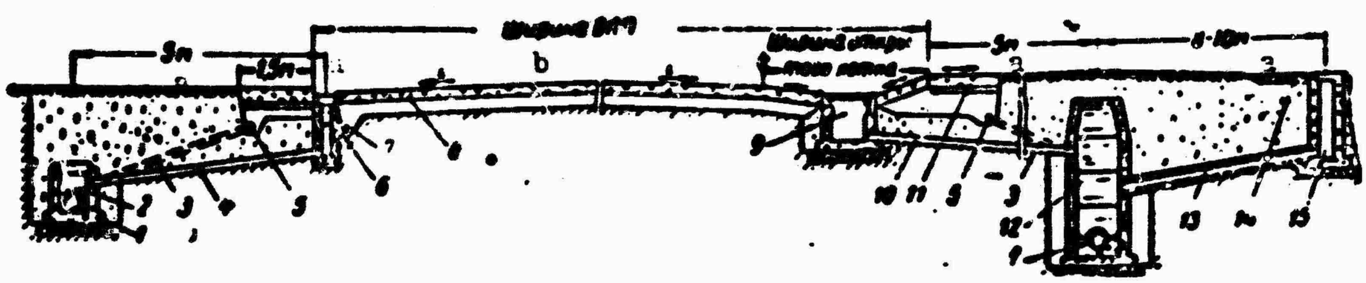


Fig. 50. Elements of a water draining network. 1) Sewer; 2) blind chamber; 3) connection to the subshoulder drain; 4) drainpipe from covered gutter; 5) subshoulder drain; 6) drain of the covered gutter; 7) covered gutter; 8) runway pavement; 9) catch basin; 10) drainpipe from catch basin into the sewer; 11) macademized soil shoulder; 12) access gulley; 13) drainpipe from drainage inlet; 14) macadam side path; 15) drainage inlet.

The network is marked out on the basis of the stacking out drawing and the longitudinal profiles of the network. Instrument marking of the axes of the drainage network route is performed in conformance with the following requirements:

temporary monuments, connected by leveling lines with permanent

the restored axes and turning angles of the route should be assigned and connected to permanent monuments or objects for the entire duration of the construction;

the intersections of the route with existing structures should be noted by noticeable signs on the surface;

the setting out of the route and staking out the network should be formalized by an act supplemented by records of the monuments and references.

The water drainage network is restored and set out starting from the discharge toward the starting point.

In setting out for earth moving operations for laying the pipeline, the centers of turning point, junction point, initial and final access gulleys are located first.

The centers of gulleys are located according to references to the edges of the runway, taxiway and apron pavements, or to permanent monuments, which are given by the plan.

A theodolite is used to set out the axis of the future trench between the centers of the turning point access gulleys. Then the centers of the intermediate gulleys are found, for which purpose corresponding distances from turning point and junction point gulleys, given by the setting out drawing, are laid off on the trench axis. The centers of the intermediate gulleys are also staked out. All the marked off points are referenced to temporary monuments, numbered according to the staking plan and leveled.

Before establishing the boundaries of the trench and ditch digging operations, strips 10-15 meters wide are cleared of brushwood stones, stumps and topsoil, if this is necessary. Together with digging of trenches by multibucket or revolving shovel excavators the surface is graded to the width of the wheelbase of the excavator to ensure obtain-

ing the design profile of the trench bottom. The topsoil removal and grading of the surface is performed by bulldozers, scrapers or graders.

After the strip has been cleared and graded the axis of the route is restored again by placing on it marking stakes, at straight sections each 10 meters, and 5 meters each at curved sections. Further, the boundaries of pits for access gulleys, and the boundaries of trenches and ditches are staked out at the locality. For this purpose halfwidths of trenches or ditches are measured off from the staked out axis of the route at right angles. The boundaries of future cuts thus obtained are marked by stakes placed at every 20 meters, with a thin wire or twine stretched between them, which is used as a guideline in marking out a small furrow.

If the trenches will be dug by multibucket excavators, then the path of one crawler or one tractor axles is marked off, instead of the boundaries. In staking out a trench with slopes it should be taken into account that its width at the top changes depending on the depth.

In the case of access gulleys at the points where the longitudinal profile changes direction and at each stake, pegs (points) which are subsequently used for leveling are driven in flush with the ground along one edge of the trench before it is dug. After leveling, working elevations are recorded on posts driven in together with the points.

Temporary working monuments are staked out along the route for checking purposes during the time the operations are performed. The axis and the turning angles of ghe route are also located by temporary monuments. The fence is put in after mechanized digging of the trench.

The trenches of the drainage network should be dug after the section under construction is supplied with pipes, materials and fixtures needed for the laying and assembly of the pipes.

The pipes of the drainage network should be supplied to the con-

struction site with a nameplate or certificate from the producing plant. The quality of the pipes should conform to GOST requirements. Before being distributed along the route, the pipes are additionally inspected by the director of operations and by the quality control representative. It is forbidden to distribute along the route and to lay out in the network pipes and products which were found defective.

Concrete and reinforced concrete smooth pipes which are produced at the construction site or, by agreement, at plants, are subjected to mandatory strength and watertightness tests. The results of pipe tests are recorded in an act of the established form with a detailed record of all testing procedures. Deviations from the internal diameter sizes of pipes, wall thickness and other quantities should not exceed tolerances established by the applicable technical specifications for these products.

Reinforced concrete and ceramic pipes with bell and spigot joints are tested for strength and watertightness. Pipes with cracks make a hollow sound when hit and they may not be laid out in the network.

Asbestos-cement, ceramic and reinforced concrete pipes of great length are distributed by side panel trucks are tractor-drawn trailers, equipped with wooden bases with oval notches cut out in them, in which the pipes are placed. Rubber shock absorbers should be placed between the pipes and their supports. Extreme care must be taken in loading, unloading and transporting of the pipes, since carelessness results in the formation in the pipes of microcracks, which are not visible with the naked eye.

Concrete and reinforced concrete pipes (segments) up to 1 meter long are transported by placing them in the vertical position. Pipes are handled by handling clamps (Fig. 51). When pipes are transported in the vertical position it is recommended that the bottom of the body be

first covered by a layer of sawdust, covered by mats or straw. Wooden inserts are placed between rows of pipes. Depending on their weight, the pipes can be loaded and unloaded by truck cranes, self-propelled loaders or by a tractor driven cranes. The pipes must not be hit in any way in loading, transportation or loading, neither may they be dropped from any height.

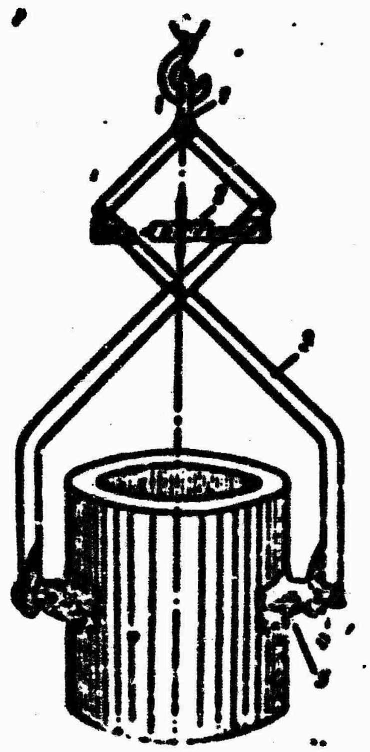


Fig. 51. Pipe handling clamps. 1) Loop; 2) expansion screw; 3) arms; 4) hinges; 5) holders.

24. DIGGING OF TRENCHES

Trenches for sewers, collectors, intercepting drains and drains must be dug in the direction from the outlet to the inlets of the drainage system, in order to ensure free flow of surface and ground water which are flowing into open trenches.

When pipes are laid on artificial foundations, trenches are dug to the full design depth. When pipelines are laid out directly in the ground the trenches are dug to a depth smaller than the design elevation by 1/4 the diameter of the pipes being laid. In this case, the bottom of the trench is brought up to the design elevations directly before the laying of the pipes. In rocky soils, when final clearing of the trench bottoms for ensuring solid support for the pipes is difficult, it is permitted to dig trenches to 10-15 cm lower than the design elevation under the condition that an artificial foundation of sand, gravel or crushed rocks will be constructed.

Trenches for constructing drainage networks within the limits of the airport and road surfaces, and also at the flying field should be dug to minimum size, so as to ensure mechanical strength of the pipelines being constructed when these will be subjected to moving loads.

For this reason the trenches are dug with horizontal walls, and wall bracing is installed if necessary. Sloping trenches are dug in laying out the network outside of the limits of the flying field.

The greatest allowable grades (ratio of the slope height to its base) of trench slopes in naturally moist soil and in the absence of ground water is the following:

	For a trench depth	
	up to 3 meters	more than 3 meters
Fill soil, sand, gravel	1:1.25	1:1.5
Sand loam	1:0.67	1:1.0
Argillaceous soil	1:0.67	1:0.75
Clay	1:0.5	1:0.67

If the upper part of deep trenches passes through stable soil and the lower part passes through weak water bearing soil, then the upper part of trenches in all cases can be dug with a slope and the lower part, starting with the level of ground water, with horizontal, braced walls.

The width of the trench at the bottom "in the clear," i.e., between the bracking boards or between the bases of the slopes, for sewers and collectors is established by the plan depending on the outside diameter of the pipes being laid, so that even space remains at the sides for laying the pipes and sealing the joints.

In the absence of design data, the width of trenches at the bottom is taken approximately as 0.8 meters more than the diameter of the pipe for pipes up to 500 mm in diameter, and by 1.2 meters wider than the diameter for pipes more than 500 mm in diameter.

If the trench walls are braced, then for depths up to 3 meters the width at the bottom is determined by adding 0.1 meters for the bracing. When the bracing is made in the form of a sheet pile, the width of the trench is increased by 0.4 meters. In trenches deeper than 3 meters,

0.2 meters are added for each meter of depth of standard bracing.

Special attention to trench dimensions must be paid in constructing intercepting drains and drains, in order to prevent excessive use of expensive draining material in constructing them. The minimal width of a trench along the bottom for pipe drains is taken as 0.4 meters more than the diameter of the pipes being laid, and for pipe intercepting drains it is taken as 0.2 meters more.

Depending on the category of the soil and the dimensions, trenches are dug by multibucket trench excavators, single bucket excavators, trenchers and graders.

The technical characteristics of chain and revolving-bucket trench excavators are given in Table 20.

TABLE 20

Тип траншейного экскаватора 1	Наибольшая глубина копания, м 2	Ширина траншей по дну, м 3	Вылет транспортера от оси экскаватора, м 4	Расстояние от конца транспортера до земли, м 5	Транспортная скорость, км/час 6	Производительность, м³/час 7
Цепные траншейные экскаваторы 8						
ЭТ-121 9	1,20	0,50	1,10	0,85	3,59—7,90	108
ЭТН-122 10	1,20	0,2 или 0,4	Шнек	—	4,56—12,95	80
ЭТН-123 10	1,20	0,2 или 0,4		—	6,32—22,3	80
ЭТН-141 10	1,40	0,43	0,765	—	3,59—7,90	108
ЭТН-142 10	1,40	0,43	1,175	—	4,04—8,88	108
ЭТН-251 10	2,50	0,80—1,10	2,46	1,56	1,90—4,65	150
ЭТН-351 10	3,50	0,80—1,80	3,62	1,93	1,70—4,18	114
ЭТН-352 10	3,50	0,80—1,10	3,05	1,85	1,80—4,20	130
11 ЭТУ-353	2,5 3,5	0,80—1,10	3,05	1,65	1,0—9,20	—
ЭТН-171 10	1,90	0,50	—	—	0,96—4,05	90,5
12 Роторные траншейные экскаваторы						
ЭР-2 13	1,65	0,85	0,80	—	1,50—6,40	220
ЭР-4 13	1,80	0,90	0,80	—	2,25—9,65	320
ЭР-5 13	2,2	1,2	1,00	—	3,20—9,40	500
ЭР-6 13	1,2	0,50	0,50	—	3,59—7,90	185
ЭТР-152 14	1,50	0,60	—	—	2,55—9,65	10—420

1) Type of trench excavator; 2) greatest digging depth, meters; 3) width of trenches at the bottom; 4) overlap of conveyor belt from the excavator exit, meters; 5) distance from the end of conveyor belt to the ground; 6) road speed, kilometers/hour; 7) productivity, meters³/ /hour; 8) chain trench excavators; 9) ET; 10) ETN; 11) ETU; 12) revolving-bucket trench excavators; 13) ER; 14) ETR.

Chain-type trench excavators are efficient when operating in I-III category soils not containing large stones.

The ETN-122 and ETN-123 excavators are installed on the MTZ-5L

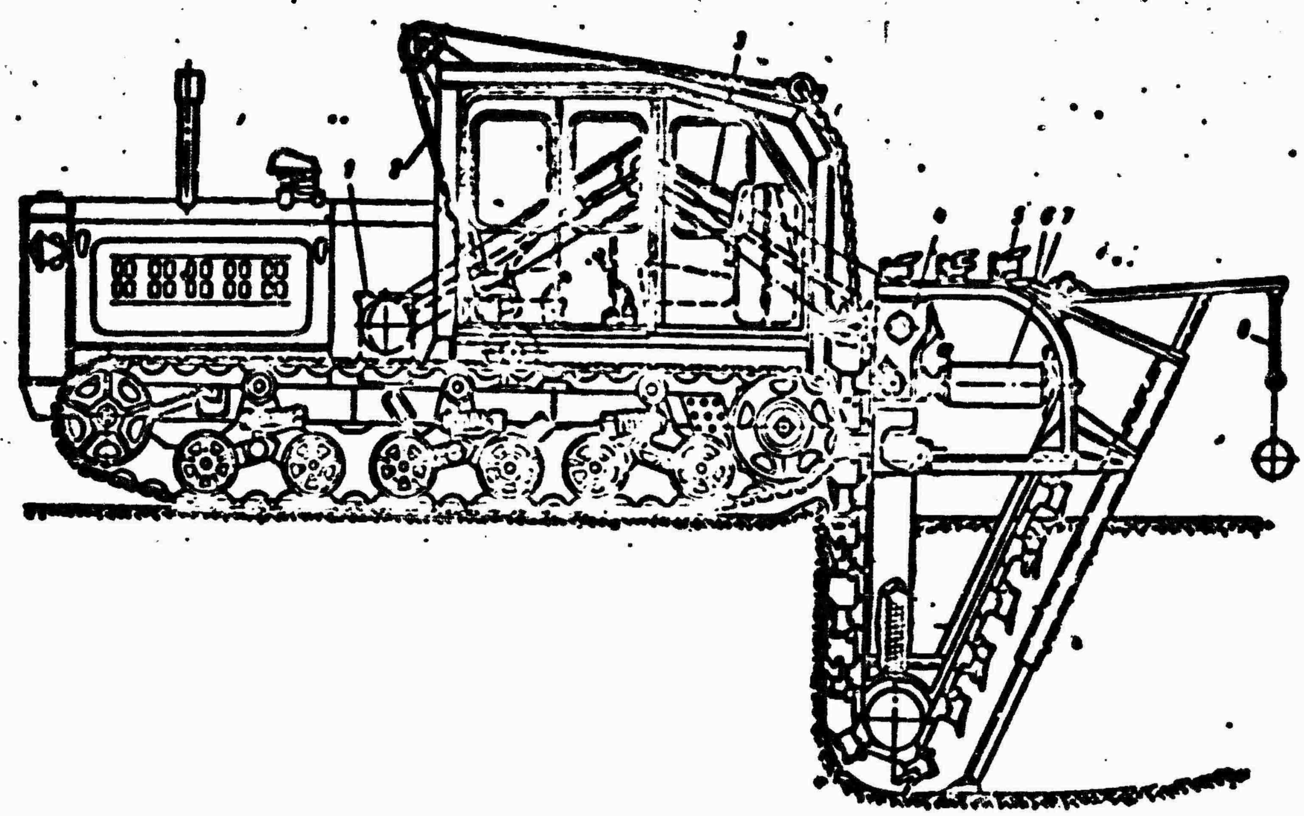


Fig. 52. The ETN-141 trench excavator. 1) Intermediate reducing unit; 2) mechanism for raising and lowering the working equipment; 3) chain drive for the working equipment; 4) drive mechanisms; 5) bucket; 6) bucket chain; 7) conveyer belt; 8) inclinometer.

"Belarus" wheeled tractor which has high maneuverability and road speed. In addition, these excavators are equipped with a blade which makes it possible to use them in grading and filling of trenches.

Excavators ETN-141 and ETN-142 used for digging trenches with a specified slope, are equipped with a special instrument – an inclinometer, for giving the slope of the trench bottom (Fig. 52).

The inclinometer is suspended from the frame of the working element which, in the presence of a load, ensures horizontal position of the instrument regardless of the excavator position. As the excavator works, the instrument's hand slides along a guiding wire, which is stretched on special metal stakes along the trench route at an angle corresponding to the slope of the trench bottom.

The ETU-353 trench excavator (Fig. 53) can be used for digging trenches with a rectangular and stepped profile (Fig. 54). The excava-

tor has three kinds of changeable equipment which makes it possible to use it in digging trenches of different depth. Using the basic equipment, the excavator digs trenches with vertical walls up to 2.5 meters in depth, and when provided for the second kind of changeable equipment, it can dig to a depth of 3.5 meters, the trench width in both cases being 0.8-1.1 meters. To dig trenches in weak and noncohesive soil, in which stable vertical walls cannot be obtained, transverse augers are mounted on the bucket frame of the ETU-353 excavator (see Fig. 53). When digging trenches under winter conditions, changeable equipment with cutters and wedges are installed on the excavator for working in frozen soil.

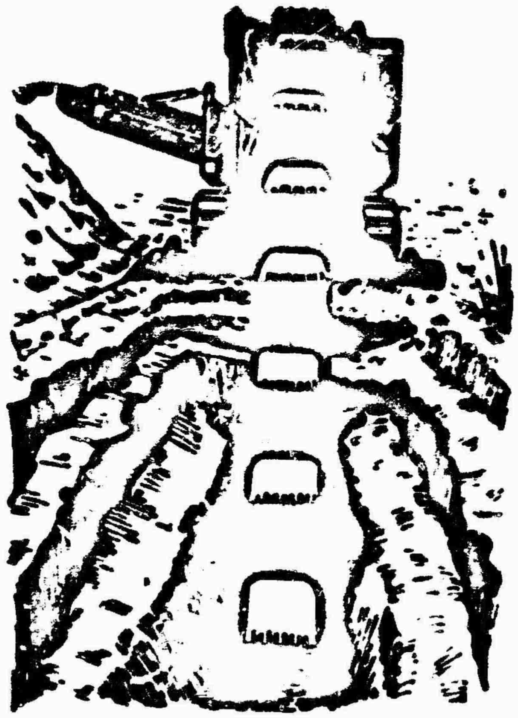


Fig. 53. The ETU-353 excavator in operation.

The ETN-171 trench excavator is equipped with a device for laying of draining pipes and with a device for automatic adjustment of the trench bottom slope.

The ETN-351 excavator (Fig. 55) is extensively used for digging rectangular profile trenches up to 3.5 meters deep.

The revolving bucket trench excavators are more productive than the chain-type excavators due to the high speed at which they dig the soil.

The ER-4 excavator serves for digging trenches in frozen soil with a freezing depth up to 0.5-1.5 meters.

It should be remembered that the majority of multibucket excavators dig ditches with a constant depth, exactly following the topography of the site, rather than following the working elevations of the

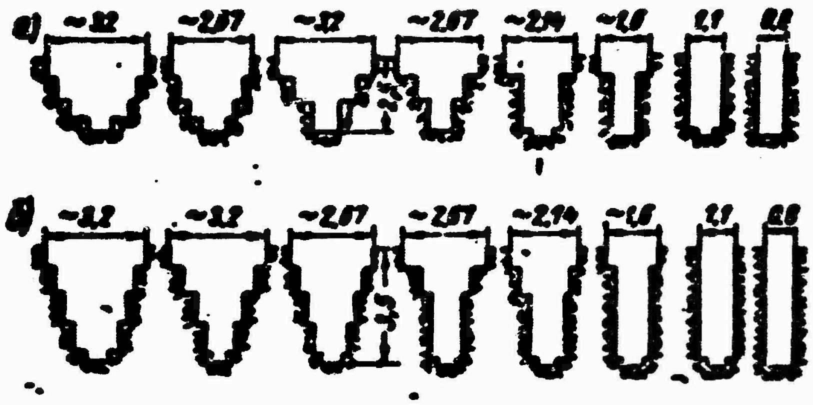


Fig. 54. Profiles of trenches dug by the ETU-353 excavator. a) For a trench depth of 2.5 meters; b) for a trench depth of 3.5 meters.

longitudinal profile. For this reason, irregularities at the surface are reproduced at the trench bottom. Manual finishing of the trench bottom after the excavator pass is very labor consuming in this case, especially in difficult clay soil and after rainfall.

Trenches should be protected from flooding and erosion by surface water by a windrow made from excavated soil, placed from the raised side at a distance not less than 0.5 meters from the trench edge. The second, lower side serves as the place for performing pipe laying work and constructing approach roads. If necessary, fencing, intercepting ditches and windrows, etc., are also constructed for temporary drainage.

In order to prevent cave-ins, excavating of trenches with vertical walls should not precede pipe laying by more than 3 days.

The trenches are widened at the location of access gulleys by a trench excavator in a direction perpendicular to the main trench (by digging a short trench section).

Single bucket excavators are used for digging large-dimension trenches. Excavators on pneumatic tires, equipped with a trench hoe are most convenient and maneuverable in the digging of ditches. The trench hoe excavators dig the soil below the level at which they stand and move along the trench axis, moving the soil into a windrow to one of

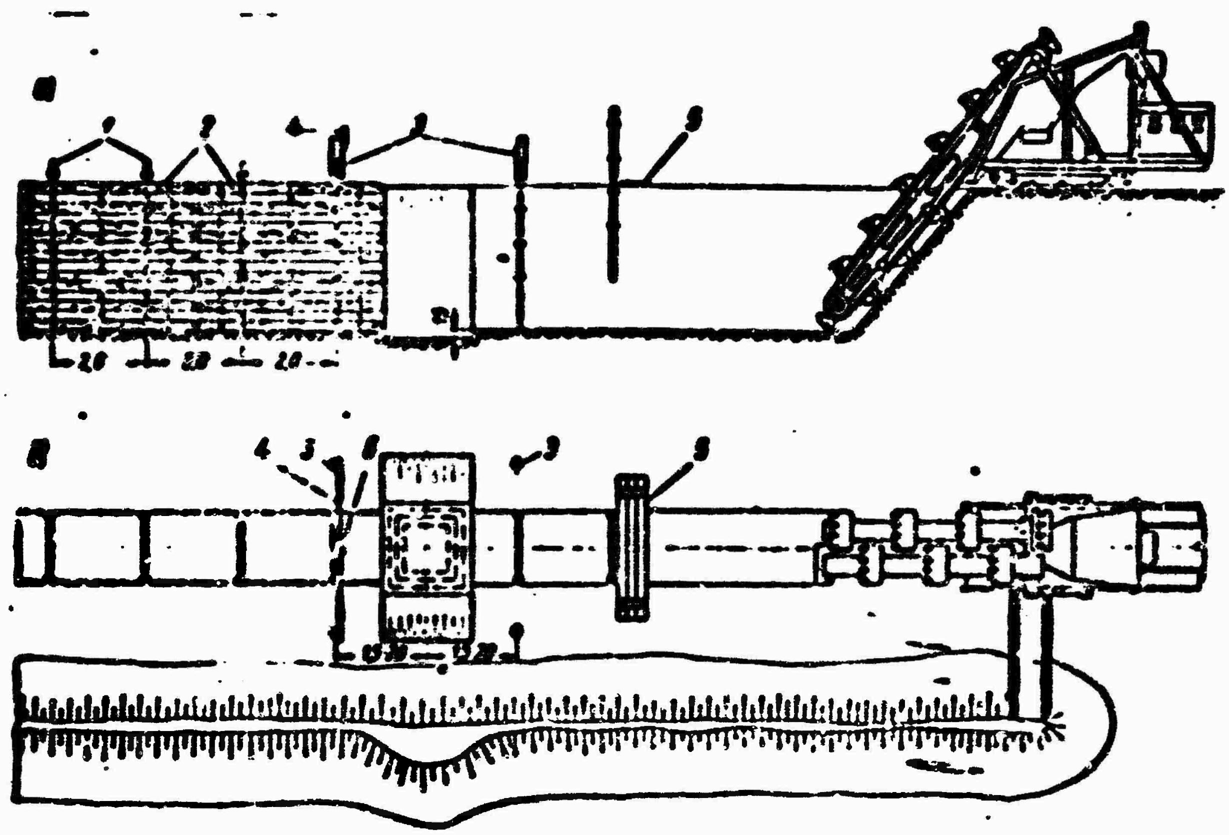


Fig. 55. Digging trenches by the ETN-351 multibucket excavator. a) Section along the trench axis; b) plan view of the trench. 1) Sliding ladders; 2) board shields; 3) sight rail pole; 4) sight rail barrier; 5) shield placed for placing of ladder-type braces; 6) shelf-girder.

Trenches should be dug by trench hoe excavators in accordance with the end face system, in horizontal layers from the edges to the middle, which ensures good visibility of the pit and makes it impossible to dig deeper or make greater slopes than necessary, and as a whole, increases the excavator's productivity. At the same time, when the trench is dug, the excavator makes it wider where necessary for the foundation pit of the access gulley.

Plow-type ditchers are used for digging of trenches for interceptor drains and drains up to 1 meter deep, and also for temporary draining of the construction site.

After the trench has been dug by machines, sight rails are placed at the locations of access gulleys, at the points where the longitudinal profile changes direction and at straight sections not more than 25-30 meters apart, which serve for checking the work being done and

and to facilitate its performance.

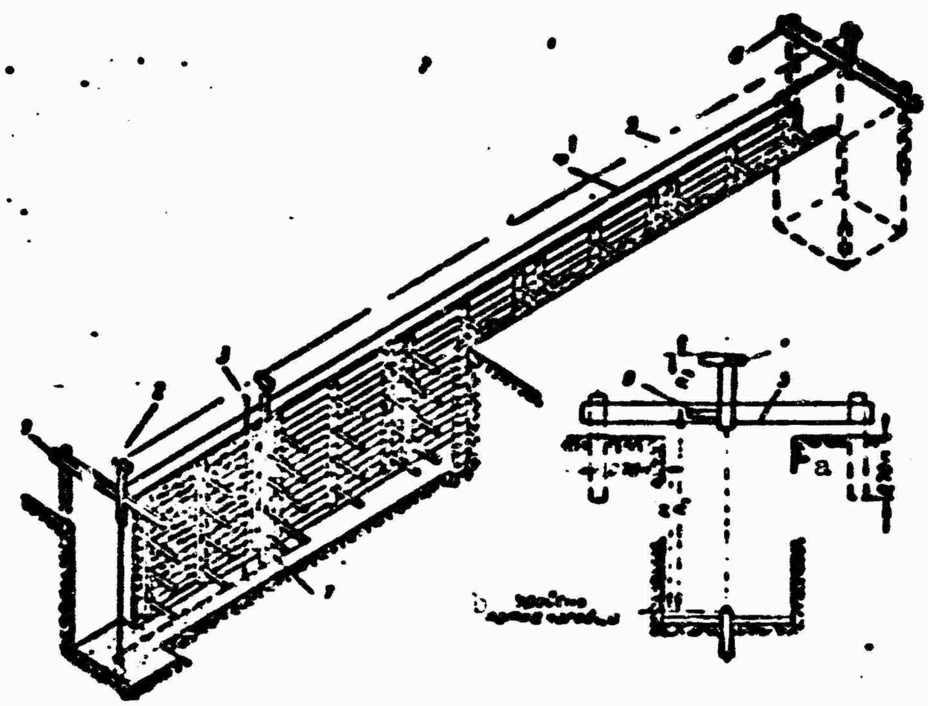


Fig. 56. Placing of sight rails and ranging rods. 1) Nail; 2) ranging rod; 3) plumb line; 4) twine or wire (alignment rope); 5) sighting line; 6) sight rails; 7) portable ranging rod; 8) shelf-girder. a) Meters; b) access gulley gutter level.

Permanent ranging rods of two adjacent sight rails are placed in a manner such that the distance between the tops of the ranging rods and the pipe gutter be the same. The length of the movable ranging rod for the laying of pipes should be equal to this distance. By placing the movable ranging rod, for earth moving operations, at any point between two neighboring sight rails, the three ranging rods (two permanent and one movable) are used for checking the width of the trench, while the movable ranging rod for pipe laying is used for checking the position of the gutter and the top of the pipe in the vertical plane.

To facilitate the sighting, the permanent ranging rod is placed not more than 1.5 meters above the ground surface. A shelf-girder, the elevation of whose upper surface is established by leveling, is fastened to the board of the sight rail at the bottom, after which is calculated the vertical distance from the shelf to the top of the permanent ranging rod; this distance is equal to the difference between the

height of the movable ranging rod and the distance between the pipe butter to the shelf. A 12-15 cm long nail is driven into the upper beam of the sight rail exactly along the sewer axis (see Fig. 56).

An alignment wire is stretched between the center nails of the sight rails, thus making it possible, by using a plumb line, to transfer the direction of the sewer axis to any point on the surface or on the trench bottom.

Sight rails of access gulleys are placed on both sides at a distance of 1.5-2 meters from the access gulley center from the lower and upper sides. The sight rails are used for determining the position of the water drainage trench during the earth moving operations, construction of access gulleys and foundations for pipes, and also in laying of pipes.

25. CONSTRUCTION OF TRENCH BRACINGS

In order to avoid cave-ins in digging of trenches with vertical walls, safety rules provide for constructing special bracings on the following soils:

1) Sand and gravel with natural moisture starting with a depth of more than 1 meter;

2) Naturally moist sand loam and clay starting with a depth of more than 1.25 meters;

3) Clay and argillaceous with a low moisture content starting with a depth of more than 1.5 meters;

4) Specially dense dry clay starting with a depth of more than 2 meters.

Overmoist sand, loam and loose soil may not be excavated with vertical walls without bracing. The trenches should be braced immediately after they are dug in conformance with safety rules. Depending on the soil properties, the width and depth of the trenches and also on the

character with which the boards or girders are placed along the vertical trench wall, use is made of horizontal, vertical and sheet pile (Fig. 57) bracing.

Horizontal bracing of trench walls is used for cohesive, nonfree-flowing soil with standard moisture (Fig. 57a).

Vertical continuous bracing is used in overmoist soil and also in free-flowing soil (Fig. 57b).

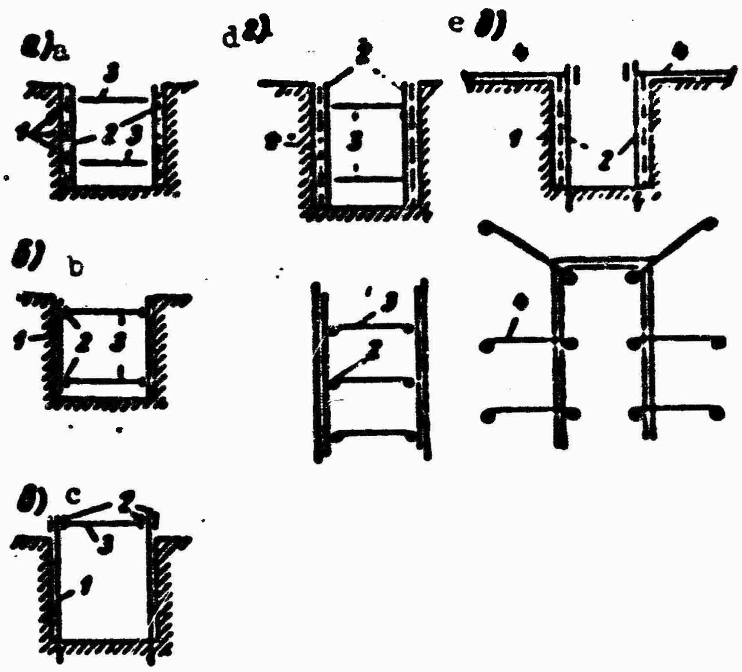


Fig. 57. Types of trench bracings by the character of board placement in the vertical wall (a, b, and c) and by the character of elements supporting the supports and girders (d and e). a) Horizontal; b) vertical; c) sheet pile; d) thrust; e) anchor. 1) Boards; 2) supports; 3) thrust beams; 4) stays (anchors).

The pile sheet bracing (Fig. 57c) is used when laying pipelines in quicksand and, when the inflow of ground water is strong. Usually the pile is driven to a depth of 50-75 cm below the trench bottom. The digging of the trench begins after the pile fence has been driven in.

A distinction is made between two types of bracings by the character of placing the elements supporting the supports and girders:

1) thrust, when the supports or piles are supported by horizontal thrust beams (Fig. 57d);

2) anchor, when the piles are supported by anchors; here it be-

comes unnecessary to place thrust beams within the trench (Fig. 57e).

In the practice of drainage network construction at airports, extensive use is made of horizontal and vertical bracings with thrust beams. Anchor fastening can be used when the trench width exceeds the length of standard reinforcements, or when laying very long pipes, when the thrust beams interfere with the laying operation.

Up to the last few years in constructing the drainage network at airports vertical trench walls were reinforced by ordinary wooden bracings, which has resulted in the use of a large amount of timber, which most of the time cannot be reused.

Better kinds of trench bracings are the standard metal reinforcements. The following are the types of standard bracings and the fields of their use:

Standard thrust beam designed by the Mospodzemstroy	for trenches up to 2 meters deep and 0.8-1.2 meters wide (horizontal bracing with spaces the width of a board)
Standard bracings designed by the NIIOMS	Continuous horizontal bracing, used for trench depths up to 4 meters and width up to 2 meters (additions are possible)
Standard bracings designed by the Transvodstroy	Continuous horizontal bracing, used for trench depths up to 3 meters and widths up to 1.8 meters (for a comparatively constant trench depth)
Standard bracings designed by the VNIIGS	Continuous vertical bracing, used in sandy and free-flowing soil and in overmoist soil in trenches 2-4.5 meters deep and 0.6-1.5 meters wide
Standard bracings designed by the Yuzhspetsstroy	Used for trenches 2.1 meters deep and 0.76-2.0 meters wide (continuous horizontal bracing)

All the enumerated standard bracings made are produced from work-

ing drawings in the workshops of construction organizations. The cost of standard bracings is by a factor of 3-4 lower than the cost of ordinary wooden bracing.

26. DRAINING THE WATER AND LOWERING ITS LEVEL

Ground or surface water is usually removed by open drainage.

The ground water level can also be lowered artificially, before the trenches are finished, by using special well points.

In open drainage, the surface or ground water flowing into a ditch is, by temporary ditches and gutters, collected into receivers, from which it is pumped out by all kinds of pumps. Ditches are dug along the walls of the dug ditches and the receivers are dug at the locations of the access gulley pits (the depth of the ditches is 15-20 cm; the dimensions of the receivers in the plane is not more than 80 × 80 cm, the depth is up to 100 cm). The walls of the receivers are braced by a bottomless wooden box, and of channels – by a wooden trough.

Diaphragm, reciprocating and centrifugal pumps are used for open drainage. The diaphragm pumps are most frequently used when the water inflow is low. They are simple in operation and can pump out highly soiled water from a depth up to 5 meters. The basic disadvantage of diaphragm pumps is their small delivery (18-45 meters^3/hour). When the work volume is small, use can be made of reciprocating pumps with a delivery of 15-20 meters^3/hour.

Centrifugal pumps with deliveries from 14.5 to 360 meters^3/hour are extensively used for open drainage. Centrifugal pumps can deliver water to large heights. The disadvantage of centrifugal pumps is the fact that before they are started up the intake pipe must be filled with water, and its end must be provided by a filter.

The automatic intake S-204 centrifugal pump has proved itself well in use. It can take in contaminated water and does not require second-

ary filling with water once it has been started. The pump is installed together with the electric motor on one cart, which can be towed by any truck. The weight of the pump is up to 560 kg, the delivery is 120 meters^3/hour, and the suction head is 6 meters.

When ground water is present, it is better to organize drainage of water by constructing the drainage system of gravel or crushed stone at the bottom of the trench. This drainage system is at the same time also the artificial foundation for the pipes being laid. When the ground water inflow is high, a pipe-type water collecting draining system, which removes the water into receivers, from which it is pumped out before all pipeline construction operations are over, is laid in the filtering material layer on one side of the trench bottom.

The ground water level is artificially lowered in the case when intensive pumping by the open method for a large inflow of ground water can result in the washing out of small soil particles which will destroy its structure in the water drainage system foundation.

Artificial lowering of the ground water level by the use of well point installations and pipe-lined wells with depth centrifugal pumps has great advantages over the open drainage. In this case, the earth moving and pipe-laying operations are performed in dry soil with ordinary, simple standard bracing and without bracing of the trench walls.

The water-level lowering wells are placed along the trench, as a rule, at one side. The well point installation consists of a centrifugal pump, intake sewer and a number of well points connected to the intake sewer and located along the trench. The distance between the wells is determined depending on the soil properties and on the depth to which it is necessary to lower the ground water level. In weakly permeable soils and, when the water level is to be lowered up to 4.5 meters from the surface, well points are placed each meter, and, when the

average depth is up to 1.5 meters and the soil has good filtering properties they are located each 2-3 meters.

The use of artificial lowering of ground water level is not effective in clay soil.

The water is pumped out from the wells continuously until the ground water level is lowered to the required depth. After the soil has been dewatered, the trench is excavated with the pumping continued until the drainage system is built.

Steel wells can be sunk by eroding the soil at the same time with water supplied through the well at a pressure of 6-8 atm. As the well is sunk, the pipe-embraced space is filled with fine gravel, thus creating the draining fill of the well.

The water from the well can be pumped out by beam-type, reciprocating or centrifugal pumps. Centrifugal pumps mounted on the same shaft with the electric motor, which are lowered into the well are most frequently used. Here the pump can be easily raised to the surface and then again lowered into the well. The current for the electric motor is supplied along an armored cable, which is lowered together with the pump. After they are sunk, the wells are closed off from the bottom with a valve to prevent soil from getting into it. If the soil does not have good filtering properties, then the space between the well and its hole is filled with sand or gravel with 6-3 mm grain size. In quicksand, this layer is placed in a surrounding pipe which is then retracted.

Well points are connected to the intake sewer made from 150-200 mm steel pipes by crimped rubberized hose or hinge-type metal pipes. The intake sewer is provided with nozzles for connecting the well points.

The water from the well point installation is pumped out by automatic intake centrifugal pump which sucks out water and air. The same pumps supply water under pressure in sinking the well points.

The automatic intake centrifugal pump does not require that the installation be first primed with water. One pump can service up to 60 well points. The delivery of the pump is 60-70 meters^3/hour. Higher capacity pumps serving up to 120 well points and lower capacity pumps serving up to 30 well points are also available.

27. CONSTRUCTION OF SEWERS AND DRAINAGE CONDUITS

Sewers and drainage conduits are underground pipelines, which receive water from the drainage network and deposit it into open ditches or directly outside the limits of the flying field into the water receiving area. Asbestos cement, ceramic, concrete and reinforced concrete pipes are used in sewer construction.

Laying of Asbestos Cement Pipes

Only pressure-type asbestos cement pipes which can take pressures not lower than 5 atm are used for constructing sewers and drainage conduits, while ordinary pipes may be used for drains and intercepting drains.

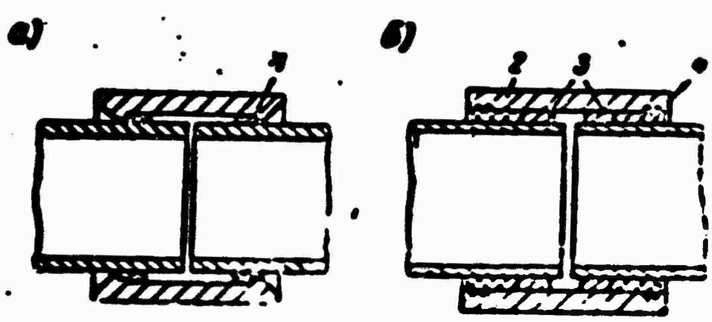


Fig. 58. Unions for asbestos cement pipes. a) Pressure pipe joints; b) ordinary pipe joint. 1) Rubber ring; 2) union; 3) packing; 4) cement seal.

Asbestos cement pipes are produced in 3-4 meter lengths with diameters up to 960 mm with flareless smooth ends. Asbestos cement twin-collar or cylindrical unions are used for joining the pipes (Fig. 58).

The asbestos cement pipes are watertight, have the necessary mechanical strength, are easily treated, have a smooth surface, are light, are not subject to corrosion, and they cost by a factor of 2-3 less

than concrete pipes, for which reason they are extensively used in constructing drainage systems at airports. The main disadvantage of asbestos cement pipes is their brittleness and low rubbing resistance.

The following operations are performed in constructing sewers and drainage conduits from asbestos cement pipes: constructing the foundation, lowering the pipes to the bottom of the trench or on the artificial foundation, laying of pipes and insertion of joints, testing the pipeline, filling of pipes and trenches. The enumerated operations are performed by the flow method. Earthmoving operations must be completed, bracings placed and access gulleys constructed before the pipes are laid in the trench. The pipe laying team consists of 6 workers.

All soil, with the exception of muddy, rocky and quicksand can serve as the natural foundation for asbestos cement pipes. An artificial foundation is constructed on muddy and weak quicksand soils, while rocky and frozen soils are replaced by sand. The foundation design is provided for in the overall plan.

The soil foundation is constructed before the laying of pipes by thoroughly leveling and compacting the trench bottom to the design depth. The pipe thus laid must be supported on the foundation over its entire length and, in the transverse direction, along an arc of at least 90°. For convenience in the joining of pipes, holes 0.2-0.3 meters deep and 0.6-0.7 meters long are dug opposite each joint point.

Before they are lowered into the trench, pipes are thoroughly inspected, tested by rapping and cleared of dust and dirt both inside and outside. The method by which the pipes are lowered into the trench depends on their weight, the work volume, the presence of bracings and, also, on the available handling equipment. Extreme care should be taken in lowering pipes into trenches.

Pipes with diameters up to 200 mm are lowered into trenches by

hand, on ropes; pipes with diameters over 200 mm are lowered by pulleys, winches or truck cranes.

When lowering into a trench by a pully or winch, the pipes are rolled onto three ties placed across the trench. A tripod with a pulley or winch from which the pipe is suspended by a cable is placed over the pipe, then the ties are removed and the pipe is lowered to the trench bottom. Pipes with diameters above 300 mm are most expediently lowered by cranes (Fig. 59) or excavators on pneumatic tires.

The crane is positioned taking into account the natural slope of the ground with its boom extended in a manner which ensures performance of operations without changing its inclination angle. The type of truck crane used depends on the weight of pipes being laid.

The crane lowers pipes into trenches without wall bracings by using a cross bar with grips (see Fig. 59). A union is placed on one end of the pipe in a manner such that its nonworking collar be directed toward the pipe laid in the trench, the union is followed by two rubber rings, after which the pipe is lowered into the trench.

If the trench walls are reinforced by standard bracing, then in order to lower the asbestos cement pipes, it is necessary to move the ladder-work and the thrust beams to the side, since the distance between them is 2 meters and the length of the pipe links being lowered is 4 meters.

When the design of the trench wall bracing does not permit [subsequent] rebracing, then a special frame-type bracing is constructed every 50-80 meters at the point where the pipes are lowered (see Fig. 60) or the trench at this point is dug with slanting slopes and then the pipes are pulled into position by winch-driven rollers.

The pipes are placed on the graded and compacted foundation from access gulley to access gulley, without gaps from bottom upward. The

first pipe is placed by one of its ends on the foundation of the lower well, flush with the internal surface of the working chamber wall.

The axis of the pipeline should be straight both in the plane, as well as in the height. In order that the pipes be laid in a straight line, a twine or thin wire (alignment rope) is stretched in the plan between the centers of railings (see Fig. 56). The position of the axis of the pipes being laid is determined by a movable plumb line suspended from the alignment rope. A template, whose length is equal to the internal diameter of the pipe link, with the axis accurately marked on it, is placed in links of large diameter pipes. The correctness of the laying height is checked by a traveling ranging rod. The traveling ranging rod shoe is placed on the gutter in which the pipe is laid and a check is made to determine whether the plane of the upper edge of the traveling ranging rod coincided with the upper edge of two adjacent permanent ranging rods placed in sight rails. If the pipe has been laid higher than necessary, then it is lowered, if lower, then sandy soil or sand is packed under the pipe. Pieces of board, stones, pieces of fallen concrete, hard soil lumps and other objects may not be used for raising the pipe to the proper height. Deviations from design elevations should not exceed ± 10 mm, and deviations in the plane should not exceed -20 mm from the pipe center.

After the pipe is centered, and its elevation is checked by ranging rods, it is reinforced by filling with soil and compacting, leaving the holes provided for joint installation unfilled. The correctness of the elevation of permanent ranging rods is checked daily before the work starts, since the sight rails can settle or can be knocked off. The pipes are laid by constantly checking the elevations of access gulley gutters by a leveling instrument, in order to maintain the design longitudinal slopes.

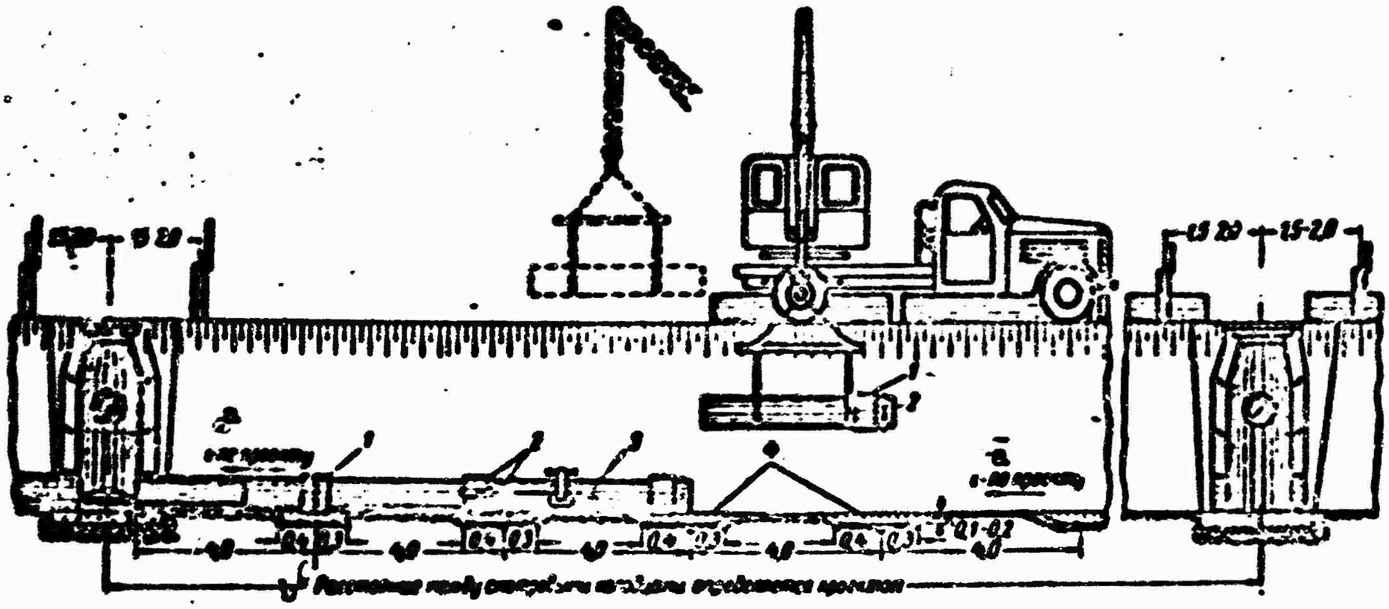


Fig. 59. Lowering of a pipe into a trench by a truck crane (the trench walls are not braced). 1) Union; 2) rubber rings; 3) tightening screw jack; 4) holes for installing joints. a) According to design; b) the distance between access gulleys is determined by the design.

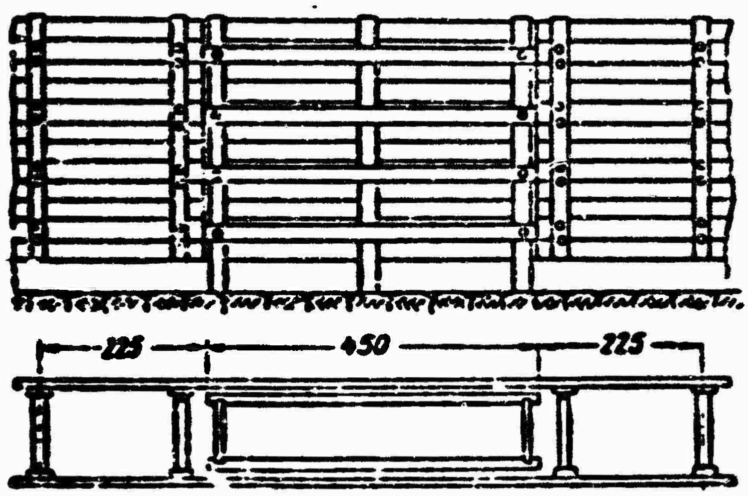


Fig. 60. Frame bracing of a trench at the point at which pipes are lowered.

For convenience in joining of pipes, marks are made in pencil at their ends in order to properly determine the position of the union when it will be pulled on.

In order to accelerate the marking off process and to avoid errors, it is performed using a wooden template, made by the installation workers. After marking, one ring is placed on a previously laid pipe with a union at a distance equal to the union length (from the end of the pipe), and a second ring is placed at the end of the freshly laid pipe

at a distance of 10-15 mm from its edge (Fig. 61).

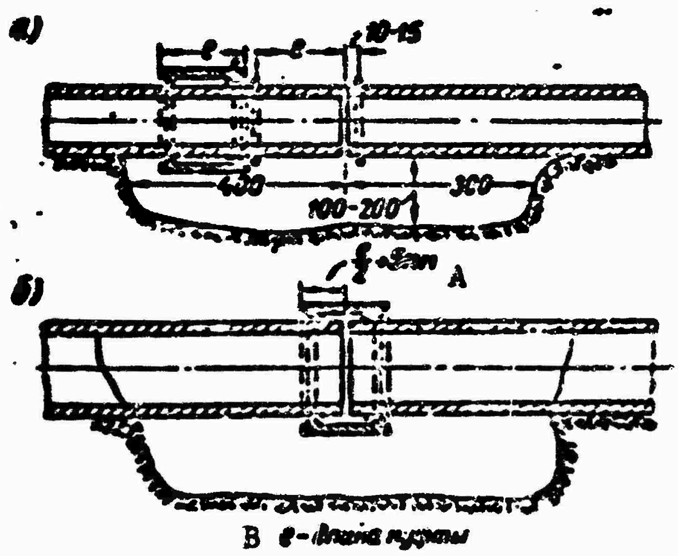


Fig. 61. Scheme for joining of asbestos cement pipes. a) Initial position; b) joined pipes. A) mm; B) e is the union length.

The ends of the pipes being joined should be dry and clean, and the rings should be placed in a straight position. Wet and moist pipes are wiped by a dry rag and are allowed to dry or are dried by ground chalk or cement.

The pipe being joined is first moved toward the installed pipe so that the gap between them should be not less than 5-8 mm. Only after checking by the traveling ranging rod and plumb line and, after the position of the pipe being joined is firmly established in accordance with plans, is the union pulled in for joining by using a lever device or screw jack (see Fig. 59).

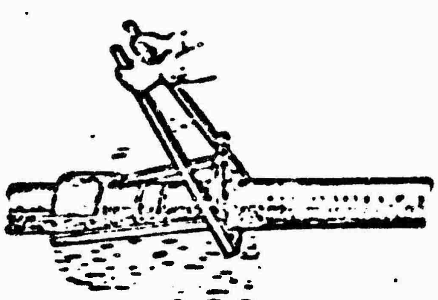


Fig. 62. Lever device for pulling in of unions.

The lever jack (Fig. 62) is used for pulling in of unions when the diameter of joined pipes is up to 300 mm. Such a jack has a number of advantages over the screw jack, consisting in the fact that it can be used at any time of the year and in any soil, due to the absence of tightening screws, and the

process of tightening the pipes is accelerated by a factor of 5. The disadvantage of the lever jack is the fact that it is difficult to move the union at a constant rate during pulling in, and the necessity of applying considerable force to the levers, especially when working with large diameter pipes.

The screw jack is used when the diameter of pipes being joined is more than 300 mm. Such a jack makes it possible to move the unions at a uniform rate. The disadvantage of screw jacks consists in the fact that it is difficult to use them in the winter due to freezing of the tightening screws and also in the summer when soil gets into the threads.

Irrespective of the jack design, it is important that the union move at a constant rate when pulled in and should at the same time grab the rubber rings. In the process of pulling in the union, care must be taken that the rubber rings do not slide but, moving together with the union, they should rotate uniformly without warping or slanting.

As soon as the union is put into position, which can be checked by marks previously made, the correctness in the ring position is checked by a sounding rod. It it is found that they are seated with a slant, the pipes must be joined anew. If the union and rings are in correct position, work is started on the following joint, additionally fastening the laid pipe in permanent position by filling soil over it. In filling and compacting the soil between the trench walls and the pipe care must be taken that this should not move and damage the pipe. A soil layer of 0.4-0.5 meters is filled on the pipe from above. This additional filling protects the pipe from mechanical damage on falling of heavy objects and also prevents possible bending of the pipeline during hydraulic tests (the pipe joints are not covered over and are left in this state until the preliminary hydraulic testing of pipelines is completed). The access gulleys must be constructed before laying of pipes.

To make it possible to move the ends of pipes inserted into the access gulleys in the horizontal and vertical directions, they are joined by an elastic watertight joint. For this purpose, the holes in the access gulleys are made by 2-3 cm larger than the external diameter of the adjoining pipes.

Oil bathed hemp packing is packed into the gap between the pipe and the access gulley wall. The end of the pipe and the walls of the access gulley ring must be first cleaned of dirt and dust and lubricated by thinned bitumen. The hemp packing should be clean, dry and without flax refuse. It is used for making a tightly twisted cord with a diameter slightly greater than the ring gap, and sufficiently long so that it can fill the gap by several layers (usually 3-4 layers).

The packing cord thus produced is bathed in thinned bitumen. Each layer of the packing cord is pushed into the gap by a metal calking iron and is packed as far as it will go by hitting it hard with a hammer weighing up to 2 kg. After the lubricated hemp packing is placed in the gap, the points at which the pipe adheres to the access gulley walls are lubricated from the inside and outside by several layers of bitumen putty (a mixture of bitumen with stone powder in a 1:4 proportion).

If the last link which joins the access gulley is found to be longer than required, it is cut off by a transverse saw.

After the asbestos cement pipes have been laid between two adjacent access gulleys, they should be immediately tested for watertightness, issued to the ordering authority and fully covered with soil. This is done to prevent possible damage (raising) of pipes when the trench is filled with water during torrential rains.

Hydraulic testing of asbestos cement pressure-type pipes is performed to expose defects in the sealing of joints (whether the rubber

rings were omitted), in the joining of pipes to the access gulleys and for exposing cracks in the pipes. The asbestos cement pipes are tested without producing water pressure and without determining the seepage rate by filling the pipeline with water between two access gulleys.

Laying of Concrete and Reinforced Concrete Pipes

Concrete and reinforced concrete pipes for constructing drainage systems at airports are produced with smooth ends, with grooves and with bell and spigot joints with diameters from 150 to 1000 mm and lengths from 1 meter and more.

Concrete and reinforced concrete pipes used in construction should be of the greatest length, which can be laid on a soil foundation. This decreases the cost of constructing foundations, joints, the water drainage, etc.

Concrete and reinforced concrete pipes are very strong and stable. The disadvantage of these pipes is the great porosity and roughness of walls, the ability to absorb moisture, difficulty in joining (with respect to ensuring water tightness of joints) and weak resistance to acids, alkalis and aggressive ground water.

When constructing pipelines from concrete and reinforced concrete pipes at sections with aggressive ground water the drainage system elements are made from concrete produced from acid resisting cement, or from ordinary portland cement, in which case, it is mandatory to insulate the pipes and access gulleys from the outside.

Reinforced concrete and high-strength concrete pipes 1 meter long are used for construction of drainage systems in the case when they are made at concrete and reinforced concrete product plants at the construction site. These pipes with smooth ends are laid on a knockup reinforced concrete foundation when their diameter is less than 600 mm, and on monolithic concrete and reinforced concrete foundations when

their diameter exceeds 600 mm. The knockup reinforced concrete foundation is constructed from 2 meter long slabs, whose cross sectional dimensions depend on the diameter of the pipes being laid. The slabs are laid after they are put through a strength test and accepted by the person responsible for the work.

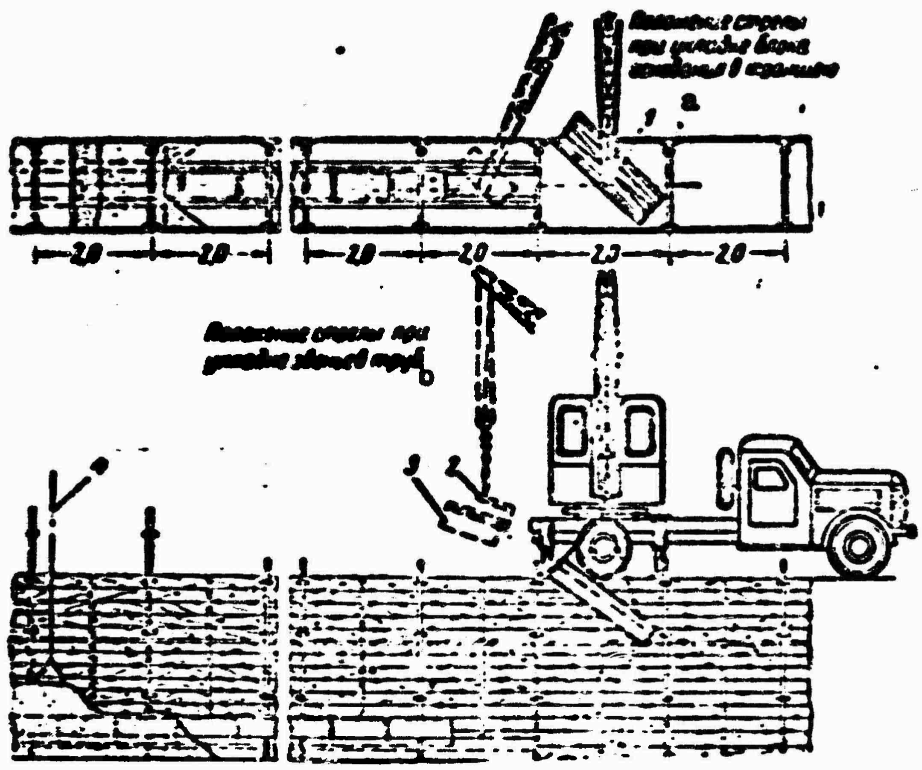


Fig. 63. Laying of concrete and reinforced concrete pipes by a K-51 truck crane on a knockup foundation. 1) Foundation slab; 2) hinge; 3) pipe link; 4) tamping plate. a) Position of boom in laying the foundation slab into the trench; b) position of boom when laying the pipe links.

The alsbs are placed in the trench by the K-51 crane supported by extension supports with the boom extending nor more than 6.5 meters (Fig. 63). Such a crane can lay 5-6 foundation slabs followed by 10-12 pipe links from one position.

The laying starts after the access gulleys are constructed from the lower side, from gulley to gulley without gaps.

The foundation slabs are laid on a layer of cement grout with the composition 1:6 or 1:8, so that 10-20 liters are poured per meter^2 of base of foundation slab. Stable setting of the slabs on the cement

grout covered soil is achieved by a vibrator placed on the slab. After final placing and checking with design markings, the foundation slabs are joined by splices made of two turns of 6 mm diameter wire or by two loops and a dowel, and gaps which are formed are filled with cement grout with a 1:3-1:4 composition on an expanding cement base. As the foundation slabs are laid, the same crane also lays the pipe links.

Before lowering into the trench all pipes are thoroughly inspected and cleaned of dust and dirt from the internal and external sides and, are numbered; each pipe is marked as to its top and bottom, and tolerances in the wall thickness are taken into account. In selecting pipes attention must be paid to the fact that the gutter in the assembled pipeline be rectilinear (due to possible deviations of the wall thickness from the design values).

The precision with which each pipe link is laid on the foundation is checked by traveling ranging rods and a plumb weight. The links are straightened out in the vertical and horizontal directions by proping them up by gravel or wedges. After the position of the pipe link being laid is checked, a leveling layer of cement grout with a 1:4 composition is poured under it.

When sealing the joints by strips of rolled material, the cement grout is poured under the joint after it has been sealed. For this purpose, a strip glued together at the middle from several layers of rolled materials (asphaltic roofing paper, water insulator, rubberoid, boruline, etc.) is placed beneath the joint. The length of the strip should be by 25-30 cm greater than the external circumference of the pipe link, and the length should be 20 cm. The strip, without bitumen lubrication, is tightened around the joint, pressing it, before sealing of joints, by large pieces of gravel or by a stone.

The gaps between the pipe link joints are filled from the outside

and inside, if the pipe diameter exceeds 500 mm, by a 1:1 cement grout with [subsequent] smoothing out. In order that the cement grout should not penetrate through the joint gap, it is covered over from the inside by a special brace (Fig. 64).

The joint is sealed 2-3 days after laying. The ends of the pipes to be joined are, for a length of 25-30 cm, cleaned thoroughly by metal brushes of dust and dirt, and are lubricated by bitumen paste or by thinned bitumen. After 3-4 hours have passed from the bitumen application, a layer of hot bitumen is placed on the soil-supported ends of the pipes and on one side of the water insulating material. Then the insulation strip is rapidly wound around the joint. The lower part of the pipe is not covered with bitumen at first, but after the insulating strip is brought underneath the pipe, hot bitumen is poured on it, which flows down under the lower part of the pipe, whereupon the strip is tightly wound around the pipe. Subsequent insulating strips are glued by bitumen similar to the first; the external surface of the strip is also covered by bitumen.

Large diameter concrete and reinforced concrete pipes with smooth ends and grooves laid on a stable foundation can be joined by strips of cement gtout with 1:2 composition. For this purpose, the joint is tightly filled with rigid cement grout from the outside, after which wooden or metal boxlike sleeves are placed on it.

The sleeves thus placed are poured over by liquid cement grout with a 1:2 composition. First the lower half of the sleeve is placed and poured over up to half of the pipe height. Then the sleeves are placed on the upper part of the strip. The grout is poured into the upper half through a hole which is left over. The strip dimensions used are given in Table 21.

The grout is compacted during pouring by knocking lightly on the

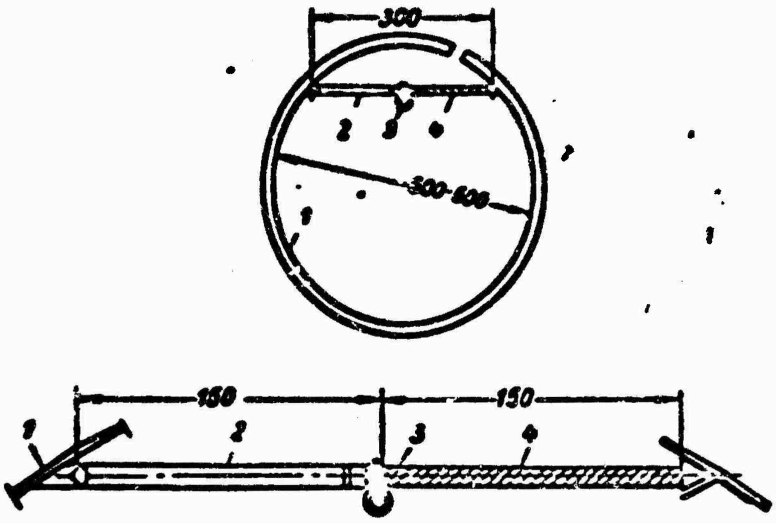


Fig. 64. Bracing for insertion of joints between pipe links. 1) Slide-off hoop; 2) bracing (a pipe with d = 22 mm); 3) clamp; 4) removable rod.

mold with a wooden hammer or by using vibrators. When the pipe diameter exceeds 500 mm, the gap between the pipes can between the pipes can be closed up from the inside and outside with cement grout, without the use of the round wooden template. For this purpose, cement grout with 1:1 or 1:2 composition is placed from the inside over the entire perimeter of the gap, and is thoroughly smoothed over and reinforced with

TABLE 21

Диаметр труб, мм 1	2 Ширина пояска, мм		Толщина пояска, мм 3
	4 в основании	5 поверху	
300	80	40	40
400	90	60	40
500	100	60	50
600	120	70	50

1) Pipe diameter, mm; 2) strip width, mm; 3) strip thickness, mm; 4) at the foundation; 5) on top.

iron. After the grout has set, the joints are sealed and the cement strip is constructed.

The forms are removed after 8-10 hours. After removal of forms, the cement strips are neither smoothed out nor reinforced with iron, but are immediately covered by wet sack material or mats, which are kept in the moist state from 4 to 8 days. The cement strip joint thus

obtained is rigid and very sensitive to various deformations (sagging, swelling, linear temperature expansions, etc.). The cement strips can be also constructed without any forms by applying cement grout with the use of sack material or special movable molds.

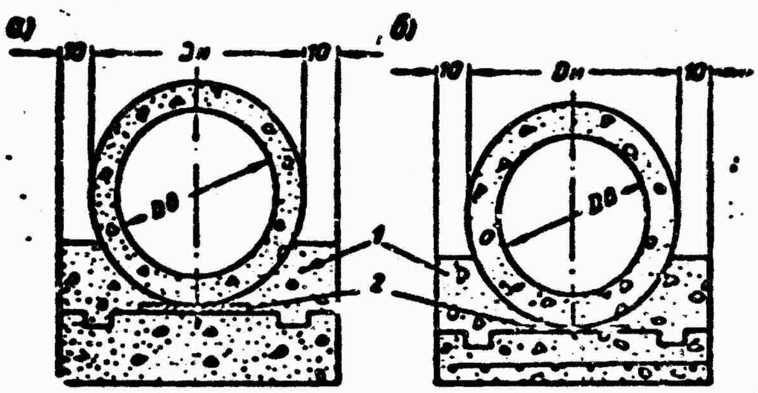


Fig. 65. Monolithic foundations. 1) Concrete; 2) cement gtout (1:3).

Concrete monolithic foundations (Fig. 65a) are constructed in laying concrete and reinforced concrete pipe links 1 meter long and with diameters higher than 600 mm, and monolithic reinforced concrete foundations (Fig. 65b) are constructed in the case of weak soil and when the fill over the pipe is lower than 1.5 meters.

In order to construct monolithic concrete and reinforced concrete foundations, a side form made from boards 40-50 mm thick is placed in the trench. The form is reinforced in the trench by pegs and lugs which are supported on the trench brackings or on its slopes. The concrete mixture is supplied to the placing point by dump trucks and is unloaded onto a wooden flooring with side panels. After the mixture on the flooring has been used up it is moved every 8-10 meters along the trench into a new position by the dump trucks. For this purpose, it is provided with skis situated along the trench and a coupling device for a steel wire or cable.

The concrete mixture is lowered at the point of placement in the foundation through wooden troughs and is leveled out inside the form.

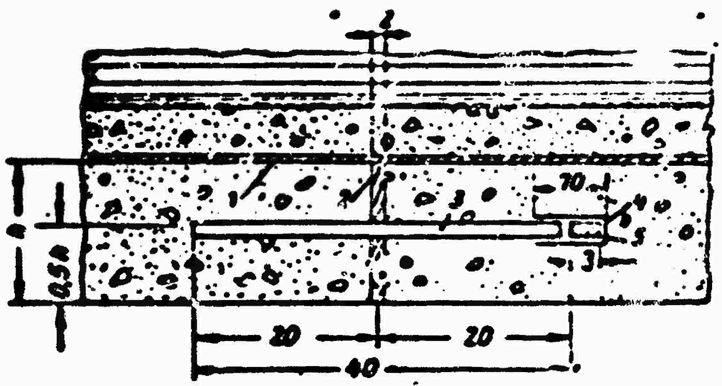


Fig. 66. Construction of an expansion joint. 1) Cement grout 1:3; 2) layer of boards, $\delta = 2$ cm; 3) dowels covered with bitumen at one end; 4) wooden stoppers; 5) a sleeve made from cardboard, asphaltic roofing paper or sheet iron.

The foundation surface is produced by 2-3 cm lower than the design elevation,in order to make it possible to produce a leveling cement grout layer in placing the pipes.

The foundation concrete is compacted by surface vibrators. Two longitudinal slots are produced when placing the concrete in the foundation by inserting wooden lathes over the entire length.

Through temperature [expansion] transverse seams with dowels are constructed each 15-20 meters of the foundation length (Fig. 66). Reinforcement mesh is placed before concrete pouring in the case of reinforced concrete foundations.

Curing of the freshly laid concrete foundation is organized immediately after final finishing of the surface. Mats or special shields providing protection from the sun's rays, wind and dust are used for this purpose. When the concrete mixture begins to set, the shields are removed and the surface is covered by a layer of fine sand 5-6 cm thick. Then the concrete thus covered is wetted by water for at least 2-3 days (in dry weather every 3-4 hours during the day and every 5 hours during the night). After the concrete curing operation is finished, it becomes possible to place the pipes on the foundation.

The pipe links are laid on the monolithic foundation and are

sealed in the same manner as this was done for knockup slab foundation. The only additional operation involved is of side gaps by concrete. Before concrete is placed in the gaps, it is reccommended that a pipeline section with sealed joints between [two] access gulleys be filled with water not under pressure. All the leaks and defects in the sealing of joints which are exposed are more easily eliminated earlier than after the gaps are lined.

Preliminary working checking of the watertightness of joints is performed by the foreman without informing the ordering authority and without compiling a covered operations act.

After the gaps between two access gulleys are lined, in order to prevent the formation of cracks in the cement collars or falling off of the rolled material strips in hot weather, for pipes provided with elastic joints, the pipes and joints should be immediately tested for watertightness, surrendered, together with an appropriate act, to the ordering authority, and filled over completely or partially, but by not less than 40-50 cm.

The pipe laying and joint sealing work is performed by an integrated team consisting of 4-7 workers (depending on the diameter of pipes being laid). The productivity of such a team working with the K-51 truck crane is 12-19 linear meters/shift.

Concrete and reinforced concrete bell and spigot pipes are laid on a natural soil foundation (with the exception of quicksand). Before the pipe is laid, the trench is cleaned by hand with attendant checking of design elevations using a traveling ranging rod for earth moving operations. A hole up to 40 cm deep and up to 50 cm long is dug under each joint before the laying of links, for convenience in sealing.

Before lowering, the pipe links are laid out along the trench with the bell part facing the slope in the same sequence in which they are

laid.

The pipe links should be lowered to the trench bottom smoothly, without jolts. The lowering method depends on the weight of the link being laid and of the handling equipment available at the construction site. The pipes are laid starting with the lowest elevations of the network.

In dry soil, the bell and spigot joints are sealed after laying 5-7 links and in wet soil this is done immediately after laying of each pipe link.

A part of the bell and spigot joint is sealed with tar impregnated hemp packing or rope. The remaining part of the gap is filled with cement grout or bitumen paste in the case of heaving soil. The hemp packing used should be clean and not contain flax refuse. A tightly twisted rope with a diameter slightly larger than the ring gap is prepared from the hemp. The length of the rope should be such that it should fill the fap in a few layers (usually in three layers). Each layer of the packing rope is pushed into the bell and spigot joint by a calking iron and packed as far as it will go by hard hits on the calking iron using a hammer weighing up to 2 kg. After the bell slit is filled with the packing, a spaee not smaller than 30-40 mm should be left for calking with cement grout or filling with bitumen paste. Rubber rings may be used to replace the hemp packing in the bell mouth. Before placing, they are put on the smooth end of the pipe being laid. The rings should press around the pipe tightly, for which reason their diameter should be by a factor of 1.2-1.5 smaller than the outside diameter of the pipe. The ring thickness used is by a factor of 1.5 greater than the bell mouth gap.

After the rubber ring is placed, the remaining part of the round gap is filled by a moistened mixture of cement and asbestos. The mix-

ture is made from 30% of asbestos fiber and from cement whose mark is not lower than 400. The mixture is moisturized before sealing the joints by addition of 10% of water by weight.

The moist cement mixture is gradually introduced into the bell mouth and are compacted until a dense mass is formed. The compacting of the hemp and the asbestos cement mixture may be performed by a pneumatic tool. If asbestos is not available, the joint can be sealed by cement grout with 1:1 composition.

After sealing the joint is covered by moss, rags or sack material and is wetted with water during 3-4 days. The joint should be covered before filling by soil. The cement joint is rigid and cannot withstand the action of aggressive ground soil. Sags and other deformations may break the joint. Cement joints are used only on good foundations.

To construct an elastic joint, that part of the bell mouth which is not occupied by the hemp packing is filled with melted bitumen paste. It is extremely important that the paste adhere well to the concrete surface, for which reason the joint parts of the pipe link are cleaned of dust and dirt and covered by liquid hot thinned bitumen not less than once a day.

The bitumen joint has good resilience, elasticity, watertightness and has good resistance to the action of aggressive water. The bitumen paste is poured into the joint using a mold in the shape of a hoop. The steel hoop, which consists of two folds embracing the pipe links, is placed flush against the bell mouth end. The joint is poured over continuously until it is completely filled. The pipelines are covered before filling over by boards, sacks, etc., in order to protect them from the sun's rays. It is better to test the finished section between [two] access gulleys and immediately completely cover with soil.

The groove-type pipes are joined by a cement collar. The internal

vertical faces of the pipes are butt joined. Before the joint is poured over by cement grout the internal seam is smoothed out and reinforced with iron in order to prevent the cement grout from leaking into the pipe.

Acid resistant cements are used in making the pipe links as well as for sealing of joints when working with aggressive soil.

Links of long reinforced concrete pipes with smooth ends are joined by reinforced concrete unions. The internal diameter of the unions should be 30-40 mm larger than the external diameter of the links being joined.

After the holes are dug, the union is placed on the end of the previously laid link, and then the pipe link which is to be laid is moved to the link laid previously, leaving a 3 mm space between the ends. The link being joined is leveled with a plumb line attached to a ranging rod and is fastened by filling loose soil around the pipe up to half its diameter (leaving the joint part exposed). The ends of the pipe links being joined are washed with water and dried, whereupon the unions are placed in position and calked by hemp packing the gap between the pipe and the union.

Ceramic Pipes

Links of ceramic pipes for water drainage systems are produced with round cross sections and with bell and spigot joints. Grooves, which are not glazed in order to improve the sealing of the joint, are left over on the external surface of the smooth end of the link and on the internal surface of the bell mouth.

Ceramic pipes have sufficient strength and watertightness, a long service life and good resistance to chemical and temperature effects. The pipe links have smooth walls and are convenient in laying. Ceramic acid resistant pipes produced from special clay are used for draining

water with dissolved acids from the airport.

Ceramic pipe links are placed on a soil foundation similar to reinforced concrete bell and spigot pipes. An additional feature is the fact that it is possible to assemble up to 5 ceramic pipe links into blocks at the surface and to lower them into the trench in this form. Blocks consisting of 2-3 links are conveniently assembled in the upright position. Blocks made up of links can be transported and lowered only after the paste at the joints has solidified. After the pipes are laid and the joints sealed, the uniformity with which the pipes rest on the foundation and the quality of joint sealing are tested by inspecting each pipe and joint.

Sewers with diameters of 600 mm and up are also inspected by checking them from the inside. Here the internal surface of the pipes should not have cracks, dents and concrete accumulations, especially in the case of gutters. The joint seams should be smoothed over with iron reinforcement.

The straightness of the laid pipe sections between access gulleys is checked by using light. For this purpose, a light source (lamp, candle) is placed at one end of the section and a mirror is placed at the other end of the section at an angle to the pipe axis.

The light disk should be reflected in the mirror in the form of a perfect circle. Displacement of the light disk upward or downward (an image in the form of an ellipse) shows that the pipe is bent in the profile, and the displacement of the disk to the left or right shows that the axis is bent in the plane.

The permissible deviations of the pipe axis in the plane are not more than 5 cm and, in the profile the deviations from the design elevations should not exceed 1 cm.

If a reflected disk is not obtained at all, this means that the

pipes at the inspected section are not laid out in a straight line.

Sewers made from concrete, reinforced concrete and ceramic pipes as well as access gulleys are tested for watertightness before the trench is filled by the hydraulic method under pressure, measuring the amount of water which is lost from the water filled sections between the gulleys.

Before the section is filled with water, all the inlets of drains, drainage conduits and drain pipes feeding into the gulley are tightly closed up. Small diameter pipes are stopped up at the outlets by stoppers made of wood with a rubber filling and covered by loam.

The stoppers are supported by wooden beams placed between the stopper and the opposite wall of the gulley. For medium and large diameter pipes, use is made of chokes made from screens assembled from sheet pile boards. The choke is constructed of two screens with a layer of treated clay in between them. The prepared section is gradually filled with water up to the level of the cover of the lower access gulley and not less than two meters above the top of the sewer pipes at the upper end of the section under testing.

The amount of water seeping through is determined by the amount of water which has to be added to maintain the level in the gulley. The testing time is 20 minutes. The watertightness is regarded as satisfactory if the seepage per 1 linear kilometer of sewer does not exceed 30-45 meters^3 per 24 hours for pipes with diameters up to 300 mm, 60-75 meters^3 for pipe diameters up to 500 mm, and up to 120 meters^3 per 24 hours for pipes with diameters up to 800 mm.

The joints which are under water pressure are also tested during the hydraulic test of the pipeline.

If the testing exposes individual points at which considerable seepage occurs through poorly sealed joints, through pipe walls and

through walls of the access gulleys, then even if the total seepage during the established time is satisfactory, the leaks must be eliminated, since seepage after the pipes are filled over and the sewer is in operation can result in breaking the joints and sagging of the pipe.

The places at which leakage occurs are found by direct inspection of the laid sewer. After the defects are eliminated the sewer is tested anew. When pipelines are laid in quicksand, the amount of ground water seeping into the network (infiltration) is checked. If water seeps in, to the pipes through poorly sealed joints and pipe and gulley walls, it carries with it small soil particles (erosion of the foundations beneath the pipes) which can result in sagging of the pipes and if the longitudinal slope is low it can also result in stopping up the network with soil. For this reason, rigid joints should not be constructed in the presence of ground water.

The network is checked for seepage (in moist soil) before the pipes are filled over, by measuring the ground water inflow in the lower gulley when the ground water level rises to their natural elevation. The ground water is raised to its natural level in the trench by making a pond. All the outlets (of drainage conduits, drain pipes) and higher lying sections of the sewer at the section under test are stopped up. The in-seepage rates and testing methods are the same as in seepage testing in the sewer. The seepage and in-seepage rates in a well constructed drainage system should be within the limits of the established norms.

Filling of Trenches

When filling pipeline trenches, extreme care should be taken to maintain the joints in operating order, keep the soil at the proper density and protect the pipes from damage when throwing soil into the trench. Displacement of the pipeline in the plan should not be permit-

ted. Complete filling of the trench is started after the pipeline and access gulleys were subjected to working tests.

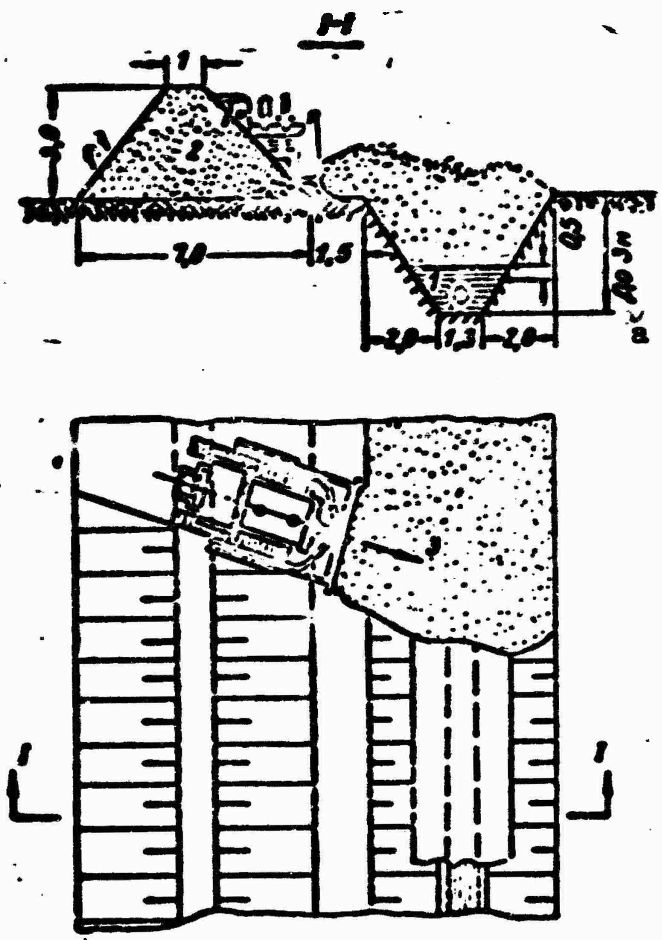


Fig. 67. Filling of trenches. 1) Point at which the soil is filled in layers by hand; 2) point at which the soil is piled when the trench is dug; 3) direction of motion of bulldozer in filling a trench. a) Up to 3 meters.

The trench filling operation is performed in two stages. The first stage is the filling of the pipeline to a height of 40-50 cm over the top of the pipes and the second stage consists in filling in the remaining part of the trench. In the case of asbestos-cement and bell and spigot concrete pipes, the first stage of trench filling starts with filling the joint construction holes with loose soil with thorough compacting by beaters and bottom swaggers beneath the joints. Then the space between the pipes and trench walls is filled in 20 cm layers up to a height of 40-50 cm over the pipe top. Wooden tamping tools with wooden handles, surface vibrators and pneumatic tamping machines are used for compacting of soil in narrow points access to which is diffi-

cult. Dry soil is compacted by layers and is moistened by water in the process.

When working with concrete pipes laid on an artificial foundation, the trench filling is started with filling the space between the pipes and trench walls with soil and thoroughly compacting it. The spaces are filled with loose soil, free of lumps, stones and other hard inclusions which is thereupon compacted to a height of 40-50 cm over the pipe top.

It is ex pedient to perform final filling of the trench at the second stage by a general purpose bulldozer with by-layer compacting (Fig. 67).

The filling of trenches beneath airport pavements is the most critical.

The trench bracings are dismantled simultaneously with filling, also taking steps against caving in of soil. The sheet pile bracing is removed in the case when its dismantling is provided for in the plan. The access gulleys and discharge structures are filled by layers simultaneously with the filling over pipes.

28. CONSTRUCTION OF OPEN MAIN AND INTERCEPTING DITCHES

Open main ditches are constructed outside the limits of the flying field in order to drain water from the outlet of the closed main sewer into the water intake. These ditches usually have a trapezoidal cross section. Their size is determined by calculation.

Intercepting ditches are constructed outside the flying field limits to protect the airport site from outside water inflow by intercepting and draining the run-off water into the natural depressions of the locality and nearby reservoirs.

Open ditches are constructed at the start of the main airport construction operations.

The entire soil removed from the ditches must be put to maximal

use for vertical grading of the surface of the flying field or the drainage system, and when the transverse slope of the locality is moderate, it should be spread out at the ditch edges producing a slope in the direction away from the ditch (without weirs).

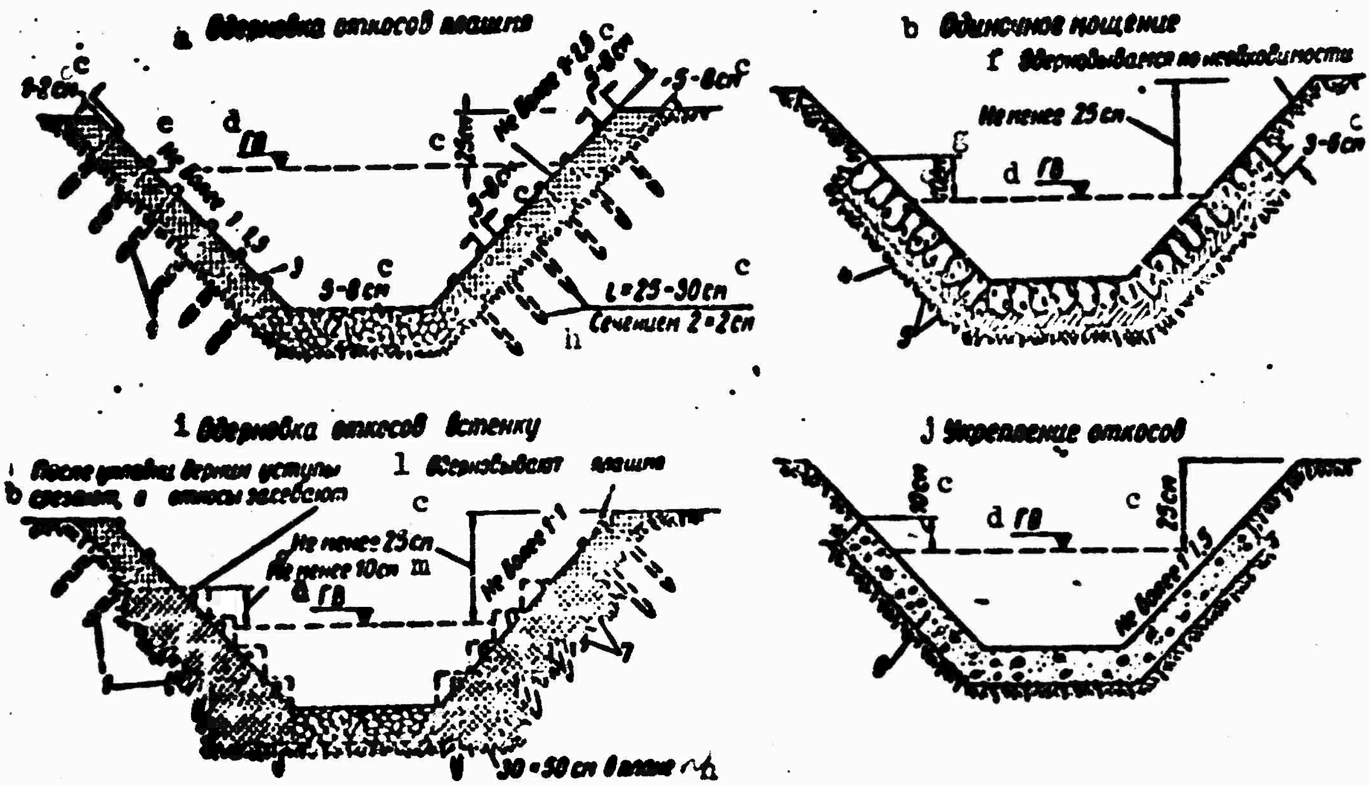


Fig. 68. Types of reinforcements for the bottom and sides of ditches. 1) Wooden stakes (driven in every 40 cm along the ditch for sod strips or 4 pieces per sod piece); 2) crushed stone, gravel, slag, etc.; 3) piece or strip sod; 4) layer of straw, moss. etc.; 5) large stones (n = 12-16 cm); 6) reinforced soil; 7) sod. a) Flatwise covering of slopes by sod; b) single-layer stone paving; c) cm; d) GV [water level]; e) not more than 1:1.5; f) is covered with sod if necessary; g) not less than 25 cm; h) 2 x 2 cm in cross section; i) covering of slopes with sod in the upright position; j) reinforcement of slopes; k) after the sod pieces are laid, the steps are cut off and the slops are sowed over; l) is covered over flatwise; m) not less than 10 cm; n) 30 x 50 cm in the plan.

When the water flow rate exceeds that maximally allowable for the given soil, the bottom and slopes of the constructed ditches are reinforced in order to prevent soil erosion. The type of slope and bottom reinforcements is determined by design. The ordinary types of ditch reinforcements are continuous sod covering or paving by cobblestones with fraction dimensions of 18-25 cm. The bottom and slopes of ditches are paved with stones to a height of 10-15 cm above the design water level

(Fig. 68). The remaining part of the slopes above the pavement is reinforced with sod up to the edge of the ditch.

Stone pavements are placed on thoroughly leveled surfaces of the ditch slopes and bottom on a layer of moss or straw. The paving starts from the foot of the slopes. The seams must be dressed.

The underlaying material may not be pressed in between the stones.

Piece or strip sod with a topsoil layer thickness of 5-8 cm from high quality meadow sod is used for sod covering. The edges of sod are cut at an angle in order to form closed seams.

Before the sod is laid, the slopes are covered with a topsoil layer not smaller than 5 cm. The sod is tightly pressed to the slope by a tamping machine and is made fast by wooden stakes 25-30 cm long. The amount of stakes used up is 15-26 pieces per 1 meter^2. Voids in seams between individual sod pieces are filled with soil.

The sod is best placed in the spring or late fall. The team consists of 4 workers. The productivity of a team per shift is up to 50 meters^2 in constructing the stone pavement and up to 228 meters^2 when sod covers the slopes.

29. CONSTRUCTING SIDE DRAINS AND INTERCEPTING DRAINS

Side drains are constructed for collecting and draining excess water from draining foundations of pavements at airports located in regions with excessive moisture, and also on argillaceous and clay soil. Side drains are laid outside the limits of artificial pavements at a distance of 1-1.5 meters from the edge. The drains are led into access gulleys of sewers; here, the height of fill over the drain pipes should be not less than 0.6 meters.

Side drains are constructed from earthen pipes 50 mm in diameter or, from asbestos-cement pipes not less than 75 mm in diameter. Slits 3-4 mm wide reaching 2/3 of the pipe diameter are cut with a transverse

saw in asbestos-cement pipes every 30 cm. The asbestos cement pipes are laid with the slits downward.

The joints of earthenware pipes and the slits in the asbestor ce-ment pipes are covered on laying with moss or tar impregnated matting in a layer of 1-2 cm in the dense state.

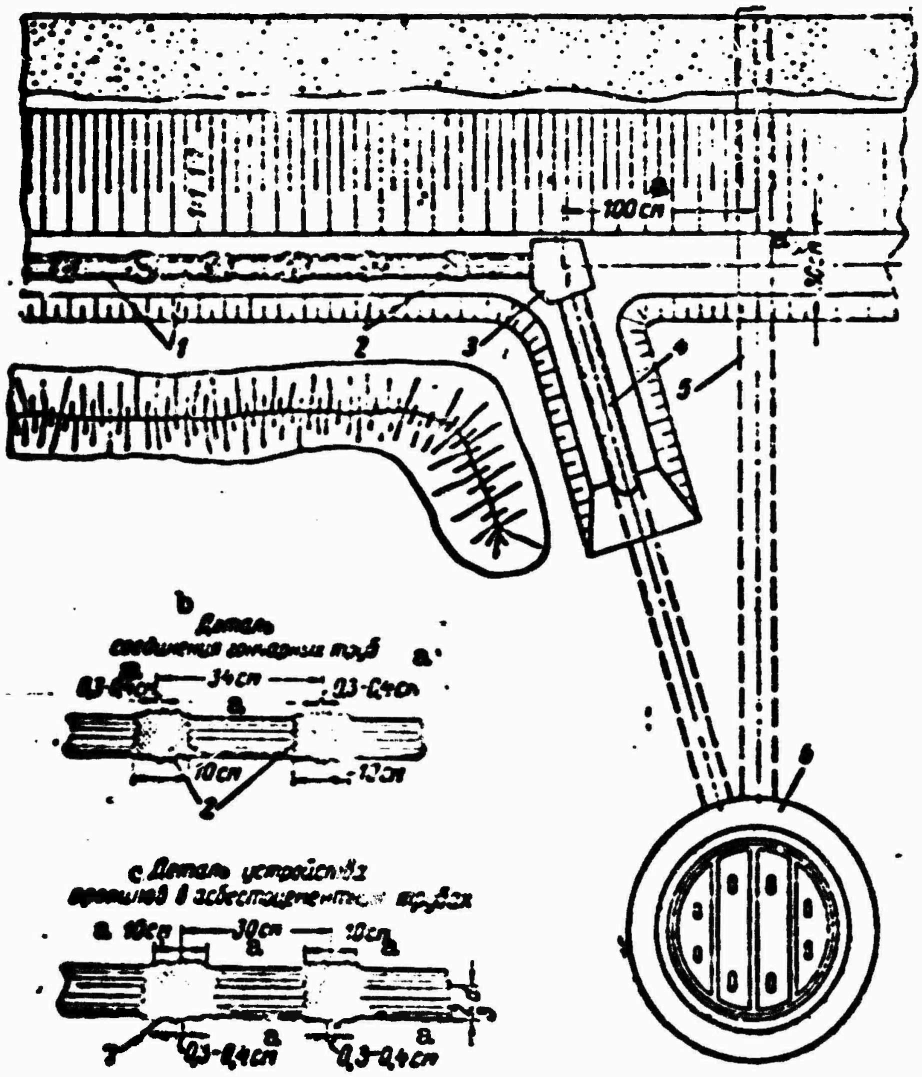


Fig. 69. A turn in a side drain constructed from facing stones. 1) Earthenware (d = 50-75 mm) or asbestos cement pipes (d = 75-100 mm); 2) moss collars; 3) facing stone; 4) asbestos cement pipe (d = 75-100 mm); 5) the same as above except that d = 200 mm; 6) access gulley; 7) slits. a) cm; b) detail of a joint in a earthenware pipe; c) detail of constructing slits in asbestos cement pipes.

A turn in a side drain is produced by using facing stones or by a smooth bend with a radius not less than 1 meter at an angle larger than 90°, made from sections of asbestos-cement or earthenware pipes 30-32 cm in length (Fig. 69).

Construction of side drains consists in the digging of the trench, laying of pipes and sealing the joints, filling the trench with draining material, final filling of soil into the trench, and construction of the covering pavement.

The digging of trenches starts only after the section has been fully supplied with all the materials necessary for constructing the side drain. The trench digging should not precede pipe laying by more than one shift. For this reason, all the necessary pipes, moss and draining material should be supplied to the section during the preparatory period.

The trenches are dug by machines. In order to prevent cave-ins, the internal trench slopes are constructed with a 1:1-1:2 grade and the external slopes are reinforced by sod or grass.

When ground water whose level is less than 0.6 meters away from the subpavement trench bottom is present at sections where runway, taxiway and apron pavements are to be constructed and also when the perched water table of a long fall and spring season is at a high level, single side or intercept drains are constructed.

In intercepting ground water which flows under the pavement from the side along its edges, subgrade intercept pipe drains are constructed. When a water-resistant layer is available at moderate depth, the drains are laid in this layer. The cross section of subsurface drainage pipes are determined by engineering calculations. Earthenware and asbestos cement pipes are used for this drainage system. The pipes are laid on a thoroughly prepared foundations (in weak soil the foundation is reinforced by a 10 cm layer of tamped crushed stones), pressing tightly one against the other; here the pipe joints are not wrapped. After laying the pipes are filled to both sides and from the top by draining material.

The drains are filled over with draining material in layers (10-15 cm) bringing the fill up to the level of the pavement foundation surface. Each layer is compacted by surface vibrators or by hand tamping tools.

The drains can also be constructed on the unpaved part of the flying field in the form of a systematic draining system for the entire drained area (analogous to the surface drainage network). The purpose of constructing a systematic drainage system is to drain away excessive water from the surface and ground pores and to uniformly lower the ground water level at the drained section. The draining trenches can in this case be backfilled with soil.

A 6 cm thick layer of moss or sod is spread between the soil and the fill. The pipes are laid before the level at which the soil freezes over.

The entire process of constructing the side or subsurface drainage system is performed by an integrated brigade of combined skills consisting of 6 workers.

During the first part of the workday, two workers prepare the asbestos cement pipes: they clean it of dust, cut the slits with a transverse saw with the pipes placed on a saw horse and lay them out slongside the drain axis on the edge of the pavement; three workers finish off the trenches and grade the foundation after the trench excavator has dug them.

Starting with the second half of the workday, three workers lay the pipes, seal the joints, place and compact the draining material layer by layer, and the other three workers continue the filling of the trench. The productivity of this brigade is 100-120 linear meters of side or subsurface drains per shift.

Intercepting drains serve to intercept and drain away surface wa-

ter from the flying field. They can be made of pipes as well as without pipes.

Pipe intercepting drains are constructed in the same manner as the drainage system, from ceramic, earthenware or asbestos cement pipes 75-100 mm in diameter.

Pipeless interceptor drains are constructed at noncritical sections of the flying field of permanent airports with dense soil and also at temporary landing strips. The filtering material is filled into the intercepting drain immediately after the digging of trenches. The time interval between digging and filling should not exceed one shift, since open trenches which are not filled cave in very rapidly.

To provide for high stability of the flying field surface, the upper part of interceptor drains is treated with hot bitumen (6-8 liters/ /meter^2) by the impregnation method, or are covered with sod, leaving a water intake slot up to 30 cm wide. The interceptor drain may not be completely covered with sod, since this will result in poor operation.

30. HYDRAULIC STRUCTURES ON THE WATER DRAINAGE NETWORK

The main hydraulic structures of the drainage network of an airport flying field are access gulleys, standard and reinforced type catch basins, discharge installations of main and intercepting ditches, connections of intercepting drains with drainage conduits, etc. All the hydraulic structures serve for inspection, maintenance and repair of the water draining network during the time it is in service.

Constructing the Access Gulleys

Access gulleys are assembled from slabs produced at the construction site, or are made in one piece, by pouring concrete on the spot. Access gulleys constructed from slabs are used when their height is not less than 1.36 meters.

When several large diameter sewers are discharging into a junction

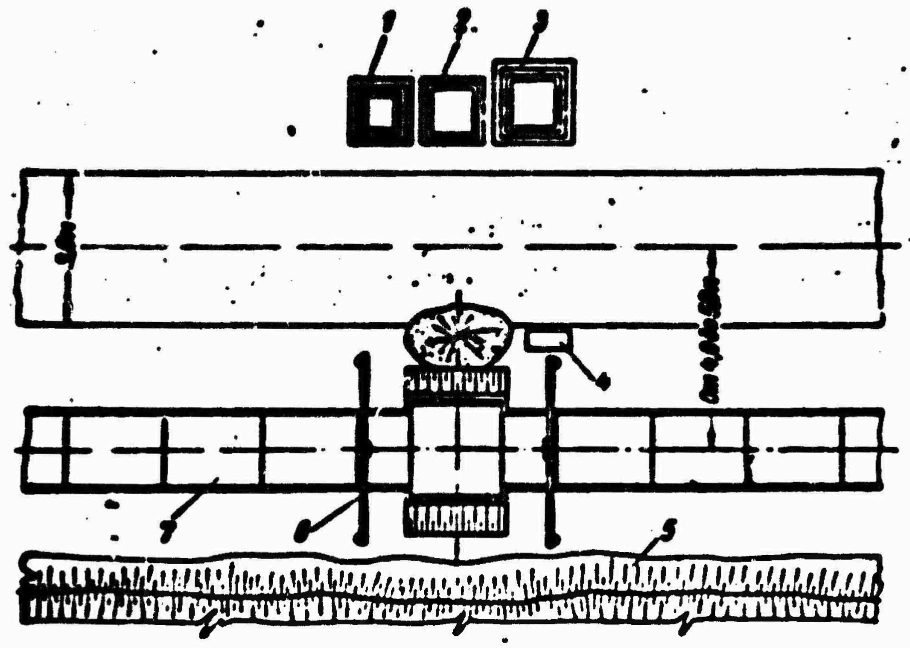


Fig. 70. Scheme of preparatory operations in constructing an assembled access gulley. 1) Upper section; 2(middle section; 3) lower section; 4) box for the mix; 5) soil pile; 6) sight rail; 7) trench. a) from 4.0 to 5.0 meters.

gulley, it is made in a single piece by pouring concrete on the spot in accordance with individual working drawings.

The access gulleys should as a rule, be constructed before the pipes of water run-off and draining networks are laid.

Operations pertaining to the construction of an access gulley consist in marking off of the gulley axes, digging the pit, constructing the pit wall bracing, a crushed stone or gravel subfoundation, reinforced concrete foundation, the working chamber and the throat of the gulley, the gulley cover, filling the gulley and the construction of a pavement around the access gulley.

The construction of the access gulley begins after the sewer trench has been dug and is ended before the pipes are laid.

Before the access gulley produced from precast slabs is constructed, its axes are staked out, sight rails are set in place, the pit walls are braced if necessar., and the gulley sections and foundation material is brought in (Fig. 70).

A gulley pit may be dug with vertical walls without bracing in dry

dense soil for a depth of up to 3 meters. For a trench depth over 3 meters in unstable or overmoist soil, the vertical pit walls are braced. The gulley pit is dug to the design elevation. The bottom level is checked by a leveling rod and a sighting rod.

The gap between the leveling rod and the pit bottom surface should not exceed 2 cm. Leftover soil can be dug out, while excessive depth is eliminated by increasing the thickness of the crushed stone or slag subfoundation.

The dimensions of the pit in the plan should correspond to the dimensions of the crushed stone (slag) subfoundation. After the pit foundation is cast, the crushed stone (slag) subfoundation is constructed in accordance with plan.

In heaving soil, a slag pillow 20-25 cm thick made from graded boiler slag is constructed instead of the crushed stone subfoundation of access gulleys. The crushed stone or slag is filled in layers 10-12 cm thick with subsequent leveling out and compaction of each layer with attendant moistening with water. After the subfoundation layer has been filled and compacted to the design height, its level is checked by a leveling tool. The gap between the level and the subfoundation surface should not exceed 0.3 cm.

The conformance of the obtained subfoundation elevations to their design values are checked by traveling ranging rods between two adjacent sight rails. A 2 cm thick blanket consisting of a sand bitumen mixture is placed on projecting edges of the slag subfoundation in heaving soil.

The foundation, the working chamber and the throat of the access gulleys are assembled, by using truck cranes, from precast slabs, cast at the site's concrete and reinforced concrete product section. Before installation, the gulley sections should be thoroughly inspected. Spe-

cial attention should be paid to damage. Slabs with chipped edges and cracks may not be installed. The point at which the sections are joined should be cleaned of dust and dirt by a metal brush.

The gulley slabs are strapped to the truck crane by four installation slings. The hoisted section should hang from the slings in a strictly level position.

The lower section containing holes for the sewer pipes is first lowered on the crushed stone foundation and leveled by a level, placing large flat pieces of crushed stone under the foundation. Then the section is raised and a leveling layer of cement gtout with 1:2 composition not less than 2 cm thick is poured on the crushed stone subfoundation. Then the section is lowered and the accuracy with which it sits in both the vertical and horizontal direction is checked. Special attention should be paid to proper location of the pipe holes.

After the lower slab has been finally placed, it is seated by a vibrator placed at the surface of the section or inside the working chamber.

The middle section of the working chamber of the gulley is assembled as follows:

the ends of the lower and middle section are cleaned with a metal brush (the ends of the sections are provided with projections to prevent relative d splacement of the sections);

a 1-1.5 cm layer of cement gtout is placed on the upper edge of the bottom section;

the middle section is lowered by the truck crane and placed on the bottom section; the cement gtout which is displaced from the joint by this action is smoothed over by a trowel on the outside and inside of the gulley.

The upper section of the gulley is assembled similarly. The cor-

rectness of section placement is checked during the operations by a leveling rod.

After the correctness of placement has been checked in the plan, and with respect to the elevation, the sections are joined together by brackets or by welded cover plates (Fig. 71).

In connecting with brackets (Fig. 71a) the existing holes in the sections are cleaned of dust and dirt and are washed with water. The ends of the brackets are cleaned of rust and dust. Then the brackets are placed in the holes provided for in the sections and are sealed with wet expansion cement, compacting with a special calking iron. The diameter of holes in the sections should be by 2-3 cm larger than the cross section of the bracket. The external part of the bracket (along the vertical slot) is covered with cement gtout with a 1:3 composition to create a corrosion resistant layer not less than 2-3 cm thick.

The gulley sections can be joined by cover plates (Fig. 71c), welding them to anchor hooks. After welding, the slots in which the cover plates are placed are sealed with cement gtout to create a protective concrete layer to prevent corrosion of the cover plates and anchor hooks. Access gulleys constructed from precast slabs are economical and ensure rapid and flow construction of the water drainage system at airports.

The bottom sections of gulleys are usually of different height in accordance with the topography of the site, for which reason each bottom slab should be produced at the casting area in forms of different length.

This is the reason why the lower section of a gulley is sometimes poured on the spot which, however, is not in conformance with industrializing of construction methods.

All the operations involved in the construction of access gulleys

are performed by an integrated brigade of various skills consisting of 4 workers. The productivity of a brigade is 2-3 access gulleys per shift.

When the access gulley is poured on location, a side form made from boards 40-45 mm thick supported by lugs, which rest on the bracings or on the pit walls, is constructed.

The concrete mixture for pouring the foundation is supplied to the pit through wooden troughs or by using buckets. The supplied concrete mix is distributed uniformly, compacting first by a rod and then by a surface vibrator. When the concrete sets, the foundation is covered by a 4-5 cm layer of fine sand which is kept moist. After the concrete or reinforced concrete foundation hardens, a wooden screen form is constructed for pouring the working chamber.

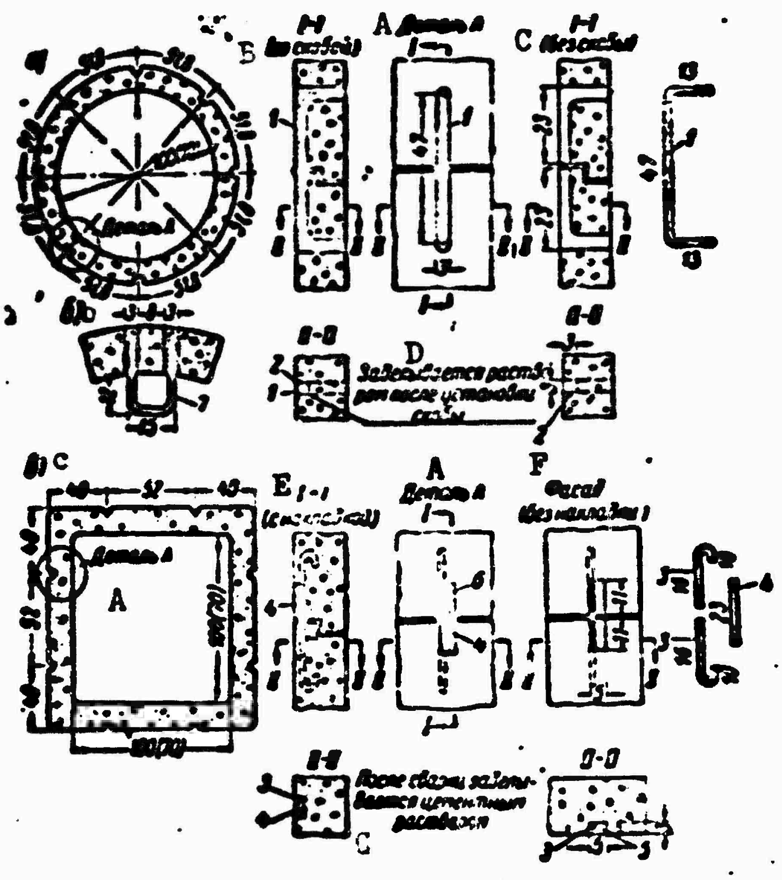


Fig. 71. Details of butt joints of gulley sections. a) With a bracket; b) detail of a sliding bracket installation; c) with a cover plate. 1) Connecting bracket (ϕ 16, l = 73 cm, 8 pieces per section); 2) bracket slot; 3) anchor hook (ϕ 16, l = 26 cm, 16 pieces per section), is welded to the gulley reinforcements; 4) cover plate (ϕ 16, l = 23 cm, 8 pieces per section); 5) slot; 6) welded seam; 7) sliding bracket. A)

Detail A; B) (with bracket); C) (without bracket); D) is sealed with grout after the bracket is placed; E) (with cover plate); F) front (without cover plate); G) after welding, it is sealed by cement grout.

Wooden stoppers wrapped with tar paper are placed at all points where pipes of drains, intercepting drains, drainage conduits, drain-pipes and sewers are connected to the gulley. When a sewer with large diameter pipes is connected to the gulley, the wooden stoppers are replaced by the pipes proper, whose ends are wrapped with roll material, in order to provide a gap of not less than 2-3 cm between the pipe and the gulley wall.

The concrete mix is packed into the forms in layers of 15-20 cm and is compacted by sticks and vibrating pins. After concrete has been packed to produce the working chamber, forms are installed for pouring the throat and top of the gulley. The forms are reinforced from the inside by thrust bars and from the outside by metal hoops from strip iron. The throat and the upper part of the gulley should be poured with special care. The forms are dismantled when the concrete strength reaches 20-25 kg/cm^2, carefully, without hitting them by a hammer.

After the forms are removed, the external surface of the gulley is covered by mats or by sack material, which is kept in the moist state for 6-8 days. The access gulleys are temporarily (until permanent covers are constructed) covered from the top by wooden screens.

Not less than 5 times per 24 hours the internal surface of the gulleys should be generously poured over with water. After 6-8 days, a gutter which, within the limits of the gulley, replaces the sewer pipe, is cast in all access gulleys of the main sewer, using a wooden template. The bottom cross section of the gutter is semicircular in shape with a diameter equal to the internal diameter of the sewer pipe; the gutter walls are provided with a weir, with a slope of not less than 0.03 away from the gulley walls toward the gutter. The turns of

gutters in corner and junction gulleys should be smooth, the turning angle should not be less than 90^{o}.

The surface of gutters and weirs should be plastered with cement grout with a 1:1 or 1:2 composition with iron coating.

All the joints between sewer pipes and the gulleys, as well as the connections of drainpipes, drainage conduits and drains are made elastic. The access gulley pit is filled at the same time as the sewers. Before gulleys situated below the surface are filled, they should be provided with covers.

Covers for rectangular gulleys are made from rectangular reinforced concrete plates, and round (single-piece or welded) covers are used for round gulleys.

Before filling, if this is provided for by the plan, water insulation (a bitumen layer) is put on the outside surface of the access gulleys.

In constructing access gulleys whose covers protrude above the surface after filling, a crushed stone pavement 20 cm thick and 0.7-1 meters wide must be constructed around them. The pavement surface is treated by impregnating with bitumen to a depth of 6-8 cm. Covers of access gulleys at the beginning of the network, at turns and at depressed surface levels are produced in the form of a grating in order to provide for intake of surface water, and are located 3-5 cm below the design surface of the ground. These access gulleys are called drainage inlets.

Constructing Catch Basins

Catch basins are constructed for receiving and draining surface water from the gutters of runway, taxiway and apron pavements into sewers.

The catch basins are constructed, after the subfoundation trench

is completed, on the axis of gutter location of concrete and reinforced concrete pavements. Pits for the basins are dug only after they have been staked out, the sight rails have been placed and after the necessary materials, tools and equipment for performing the work has been delivered (Fig. 72).

Catch basins are constructed from precast slabs produced at the site or, less frequently, they are made in one piece by pouring them on the spot. The construction of catch basins and drainpipes should be finished before the concrete is poured to produce gutters at the given section.

The composition of catch basin construction operations includes: staking out the pit, digging the pit for the basin and trenches for the drainpipes, construction of foundation, placing the basin slab, constructing the drainpipe, backfilling with soil and covering with water insulating materials.

In staking out the pit for catch basins, two sight rails are placed and pegs are driven in along the basin pit boundary. The pit dimensions are the same exactly as the dimensions of the basin foundations (see Fig. 72).

The basin pit is usually dug to the design elevation without bracing the walls. The level of the pit bottom is checked by a template sighting rod. The gap between the rod and the pit bottom surface should not exceed 2 cm. If the pit is deeper than required, this is remedied by increasing the thickness of the crushed stone or slag foundation.

The trench for drainpipes is dug to a depth which is smaller than the design depth by 1/4 diameter of the drainpipe to be used. Directly before the drainpipes are laid in the trench, its depth is brought up to the design depth, and the soil foundation is graded to provide for stable support of the pipes.

The artificial foundation of the catch basin is constructed in the form of a crushed stone foundation made from commercial grade crushed stone. The thickness of the crushed stone foundation is specified by the design.

In heaving soil the crushed stone catch basin foundation is replaced by a slag pillow 20-25 cm thick, made from sifted boiler slag. The crushed stone or slag is placed on the foundation in 10-12 cm thick layers and is compacted by layers using hand tamping tools. After the upper layer has been compacted, the template sighting rod is used for checking the level of the surface of the foundation thus obtained. The gap between the rod and the foundation surface should not exceed 0.3 cm. Conformance of the obtained elevations of the foundation surface to the design specifications is determined by a traveling leveling rod and template rod, which is placed on edge on the upper surface of the sight rails. The final elevation of the surface of the foundation thus constructed is checked by leveling.

Before the basin slab is placed in the pit, it should be thoroughly inspected and should not contain cracks, chippings, dents, blowholes and other defects. The lower face (foot) of the slab should be cleaned of dust and dirt by a metal brush.

The slab is placed in the pit by a team consisting of 3 workers using a truck crane. The slab should be strapped so that on being lowered in the pit it should always retain its vertical position, and, when moved into place it should touch simultaneously at all points.

The basin slab is first lowered directly on the foundation which was prepared. The accuracy of seating is checked from the sight rails using a leveling rod. If a slant is discovered, crushed stone pieces and wooden wedges are placed beneath the slab's edges. Then the basin is raised and, without removing the inserts, the foundation is covered

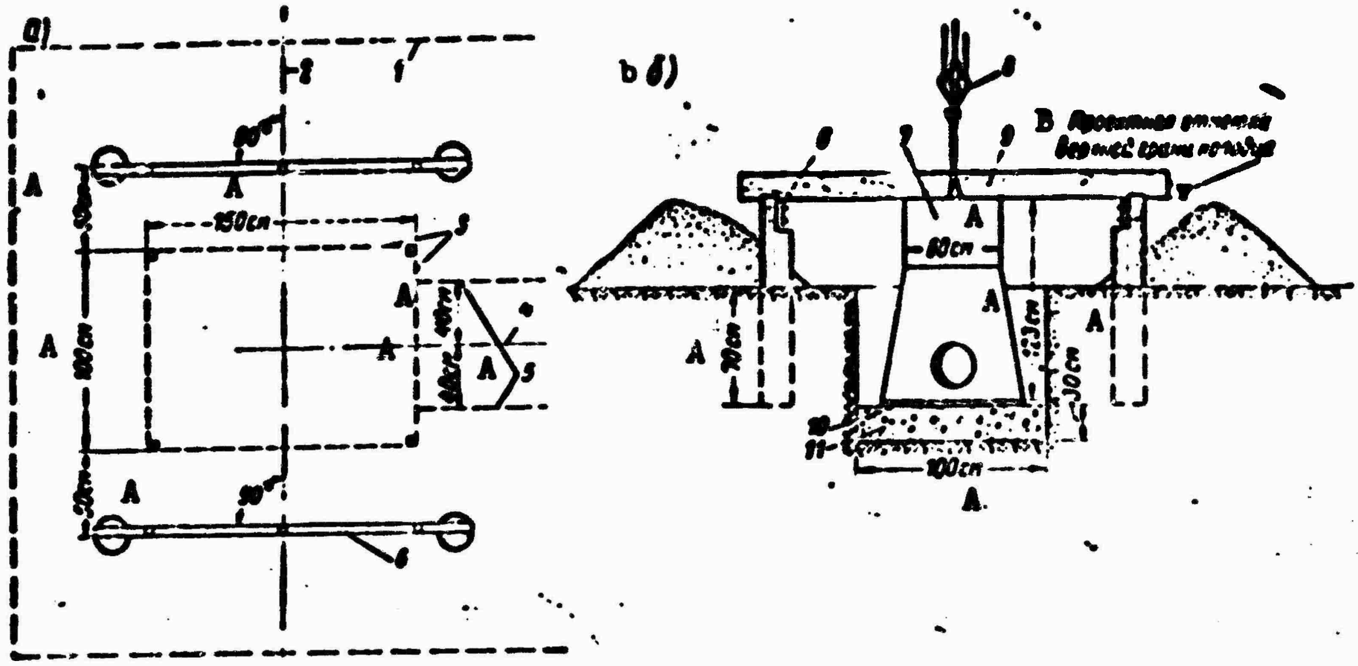


Fig. 72. Constructing a catch basin from precast slabs. a) Scheme for placing the sight rails; b) installing the catch basin sections. 1) contour of the concrete pavement slab; 2) axis of the concrete pavement gutter; 3) boundary of the catch basin pit; 4) axis of the drainpipe trench; 5) boundary of the drainpipe trench; 6) sight rail (a 5 x 15 cm board); 7) basin section; 8) truck crane hook; 9) template rod (5 x 5 cm); 10) leveling cement grout layer; 11) sifted slag foundation. A) cm; B) design elevation of the upper edge of the basin.

by a leveling layer of lean cement grout, whereupon the basin is permanently seated.

Care should be taken in the process of seating the slab that the side surfaces of the basin should be directed parallel to the sight rails and be located at an equal distance from them, and also that the basin center should coincide with the axis of the concrete pavement gutter. The elevations of the upper face of the basin being installed are finish checked by leveling; the deviation from the design elevation may not exceed 5 mm.

After the basin is seated, a sand and bitumen blanket 2 cm thick is placed along the perimeter of the protruding parts of the foundation.

The drain pipes are laid directly on the soil of trenches. The soil is dug out to the design depth and the foundation is graded by a rounding off tool immediately before pipe laying. If the drainpipes are

laid on sandy soil, then the rounding tool is not used.

The ends of pipes at the points at which they join the catch basins and access gulleys are joined by an elastic joint.

The catch basin walls are backfilled by water-resistant soil which is compacted by layer using tamping tools. The following method is used for producing water resistant soil: brand 5 liquid bitumen heated to a temperature of 100^{o}, in the amount of 5-6 kg per 1 meter^3 of sand or ash and 9-12 kg of green soap is added to fine grained sand or ash heated to a temperature of 170-200^{o}. The mixture thus obtained is thoroughly mixed, cooled and then used for backfilling the basins. The drainpipes are filled by the previously dug soil in 15-20 cm layers which are thoroughly compacted by tamping tools or vibrators and moistened with water. After the catch basin is permanently filled, a 2 centimeter water insulating sand-and-bitumen blanket with dimensions of at least 150 cm is constructed around it along the trench bottom in order to prevent erosion of soil.

The blanket is constructed by covering the graded area by a 2 cm thick layer of sand and then pouring hot bitumen in the amount of 3-4 kg per 1 meter^2 from the D-125A hand asphalt spreader, simultaneously mixing the sand with a rake.

When the pavement concrete is placed, a bitumen layer 2 cm thick is placed between the pavement and the walls of the basin along its perimeter in order to prevent water from falling into the catch basin foundation and in order to increase its stability.

The external surfaces of the catch basin are covered by a 1-2 mm layer of bitumen mastic, which are laid over a layer of bitumen paste or thinned bitumen.

In constructing pavements on argillaceous soil, the catch basins are constructed in the form of a storm sewer with a metal hinged drain-

pipe inlet (Fig. 73).

In constructing a storm sewer, an asbestos cement drainpipe is laid first; one of its ends is provided by a hinged metal inlet with a wooden end cap and the other is connected to an access gulley. A storm water inlet is constructed when the gutter is concrete poured.

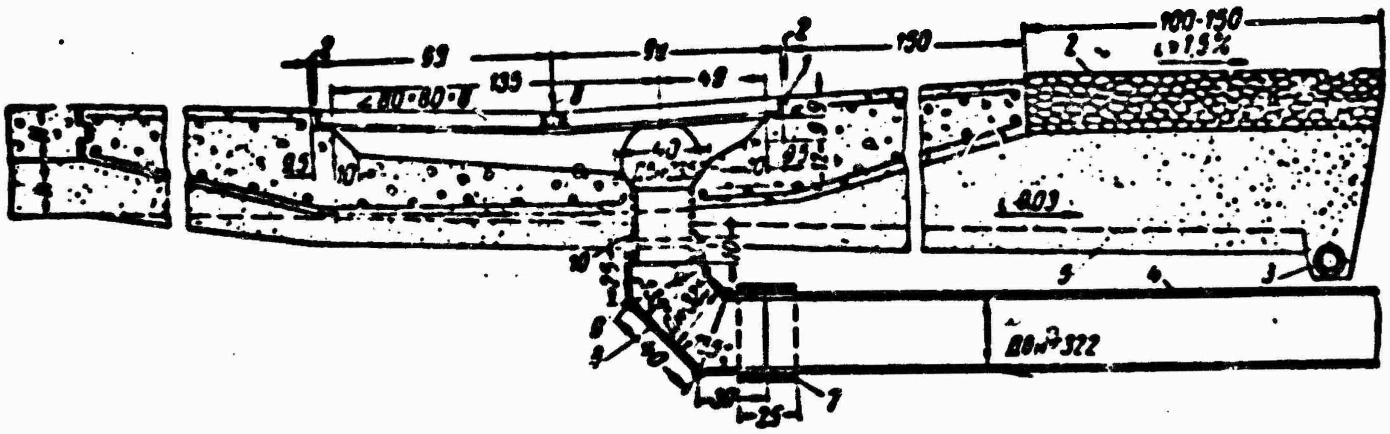


Fig. 73. Storm sewer. 1) Sealing with cement grout (1:3); 2) impregnating with bitumen (6-8 cm); 3) drain; 4) asbestos cement pipe; 5) surface of the trench bottom beneath the gutter slabs; 6) welded seams (along the perimeter); 7) reinforced bitumen joint or union; 8) an elbow welded from steel pipes; 9) bituminous yarn; 10) bitumen mastic. a) Dvn; b) dn.

Efficiency experts have elaborated a special vibrating frame, made from a wooden beam topped with the I-117 vibrator (Fig. 74) to be used in constructing storm inlets in gutter slabs.

The form is made from a single wooden beam whose dimensions are 1800 x 350 x 310 mm.

After the form is filled with concrete mix, the vibrator is switched on and the storm sewer is formed by being compacted by the vibrating frame exactly to the design size. The vibrating frame makes it possible to quality mold a storm sewer made from thick concrete mix. The concrete is vibrated for 2-3 minutes. After the gutter slab surface is finished, the vibrating frame is removed from the storm inlet and is moved over to another place. The vibrating frame can be produced internally by the construction organization.

<u>Drainage inlets</u> are constructed for draining into sewers water

from closed depressions on the unpaved part of the flying field and from soil gutter sections [located] between runways, taxiways and aprons. By their design, the drainage inlets are similar to reinforced catch basins. Drainage inlets are constructed by pouring concrete on location or from precast slabs, analogous to the manner in which catch basins are made.

In constructing drainage inlets, they are surrounded by a crushed stone or gravel pavement 25 cm thick.

The pavement should be located below the surrounding surface by 3-4 cm, and the inlet cover should be lower than the pavement surface by 3-5 cm. The pavement surface is treated by bitumen to a depth of 6-8 cm. The water is drained from the drain inlets through drainpipes into sewers which remove the water from the airport limits.

<u>Discharge installations</u> (headwalls) are constructed at points at which the covered drainage system is joined to the open main ditch.

The supporting wall and side walls are constructed from concrete, brick and aggregate filled concrete either as precast slabs or monolithic. The headwalls must be finished before the sewer pipes are laid at the given section.

Before the headwall is constructed, the open drainage ditch should be completely finished.

The reinforced concrete headwall slabs are cast at the construction site. Precast slab headwalls are very economical and effective in weak quicksand and in the presence of ground water.

When constructing a monolithic headwall, the form is made at the construction section and is transported to the pouring location in the form of individual screens. The form is assembled in the following sequence:

the screens of the support wall form are placed and reinforced by

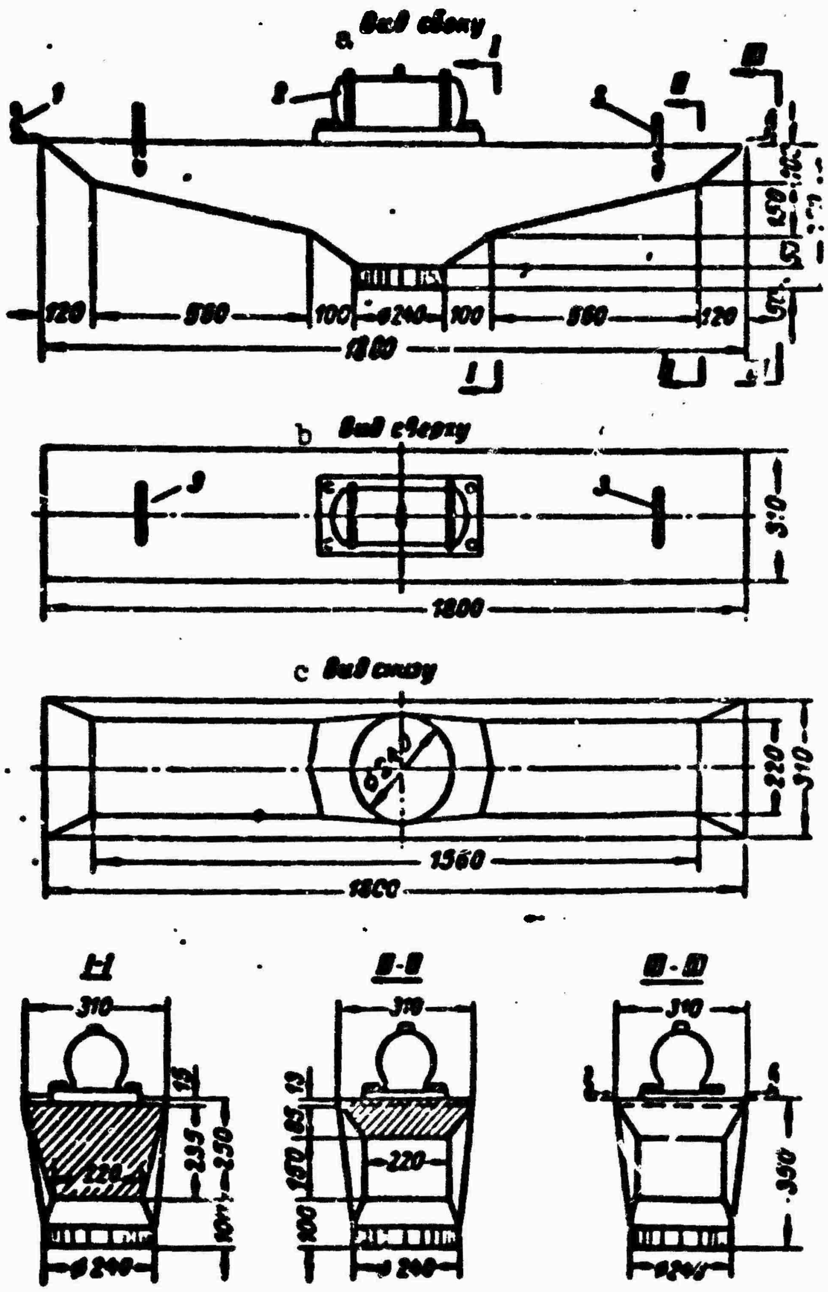


Fig. 74. Vibrating frame for constructing a storm sewer. 1) Bearing frame (made from angle steel); 2) the I-117 vibrator; 3) lever (metal, d = 16 mm). a) Side view; b) top view; c) bottom view.

a leveling instrument from a temporary reference benchmark;

the edges of the support wall form and, of the form which will produce the cylindrical hole for the sewer pipe are lined (best of all, a pipe section with a wrapped end should be placed in the mold hole instead of lining);

the form for pouring the side walls and the gutter is placed;

the form is filled from the sides by soil which is thoroughly compacted in layers.

Before the sewer pipes are laid, but not earlier than 3 days from the day that the concrete mix was poured, the form is dismantled.

The headwall is filled, the surface is graded and the slopes are reinforced simultaneously with filling the sewer pipes after they have been laid and accepted by the representative of the ordering authority.

31. SAFETY MEASURES IN CONSTRUCTING THE DRAINAGE SYSTEM, ACCEPTING AND SURRENDERING OF WORK

Safety Measures

Materials and the dug up soil may not be placed closer than 0.5 meter from the trench edge. Machines with engines in operation may be placed only outside the limit of the cave-in plane of the trench.

The trench bracings must be disassembled in the presence of the person responsible for the work of a foreman. If removal of bracings is dangerous to people and structures, then the bracings should be left in the ground.

Standard bridges with a continuous floor not less than 0.7 meters wide, and with strong railings not lower than 1 meter should be placed for the passage of workers through open trenches and ditches.

The workers should descend and ascend trenches through metal or wooden ladders with set-in steps. The trench may not be entered by way not be placed on the thrust beams of the bracing.

During the operation of multibucket trench excavators, it is forbidden to stand at the edge of the trench in the vicinity of the bucket frame and to walk beneath an operating conveyer chain.

The weight lifting capacity of equipment and devices used for lowering pipes into the trench should be recorded on them in fast paint. Workers which unload and lower the pipes should know the lifting capacity of the equipment, and also the weight of pipes and other raised or lowered slabs and parts. The weight of the pipes together with the

the straps should not exceed the lifting capacity of the equipment.

Truck cranes should not move in the process of unloading and lowering of pipes.

The pipes can be raised and lowered only by signal of the person responsible for the work smoothly, without jerks.

Workers should not be present in that part of the trench into which pipes or slabs are being lowered.

The pipe may be approached only after it lies down securely at the trench bottom.

The supports of sawing horses used for lowering of pipes should be placed on pads, placed at a distance of not less than 0.6 meters from the trench edge.

Bitumen must be heated in a boiler with a metal cover, which should be located not less than 20 meters away from structures and warehouses. The hot bitumen should be supplied to the work place in steel tanks with covers. When laying a bitumen pavement, the workers must wear gloves and goggles.

Accepting and Surrendering the Work

Systematic thorough control of all kinds of operations must be maintained in the process of work in constructing a water drainage system; the quality of conformance to design specifications of all the basic materials used, pipes, standard elements, components and other materials both obtained from plants as well as produced at the construction site must also be checked. In addition to daily control of the performance of operations, thorough documentation and intermediate surrendering to the representative of the ordering authority is required with respect to finished operations pertaining to the construction of individual elements or sections of the water drainage systems which are covered over by subsequent operations.

Documentation and intermediate surrendering is performed:

after the trenches and ditches are dug, in order to check the straightness of the sections and the conformance of elevations and grades to design specifications;

after laying foundations for pipes;

after laying of pipes and sealing of joints;

before the pipes, gulleys and basins are filled and after filling of trenches.

The surrender and acceptance of drainage systems are formalized by an act.

The following must be presented when permanent operation is to begin: all the engineering design documentation of the drainage network, working drawings with modifications and supplements to the plan which have arisen during construction, acts pertaining to covered over work, acts pertaining to preliminary working tests of the sewer and drainage conduit pipes. Selective hydraulic tests of the sewer are performed during acceptance, should the commission require it.

The tests are performed with water under pressure, as in the case of the working tests, which were described above.

Observation of seepage begins a day after the section under test hass been filled with water. The correctness of the network's slopes is checked by leveling of the gulley gutters.

32. ORGANIZING THE DRAINAGE NETWORK CONSTRUCTION OPERATIONS

As a rule, the drainage network is constructed by the flow method. Organization of flow work in the construction of sewers and drainage conduits is a part of the work organization plan for the construction of the flying field. The drainage network is constructed before the earth-moving operations and this is done at a rate which ensures execution of all drainage construction operations before the grading work

begins at the successive earth moving operations section.

The flow operations consist of the following:

digging of trenches and ditches and bracing them;

construction of outlet installations

construction of access gulleys, drainage intakes and catch basins;

constructing an artificial foundation for the sewer pipes;

laying of sewer pipes (leading process);

sealing of pipe joints;

hydraulic testing of the laid sewer sections;

filling of the sewer trenches;

grading and restoration of topsoil.

The drainage network is staked out on each successive work section in accordance with the features of the plan of the entire drainage network of the airport as a whole.

The dimensions of sections and the sequence in which the sewers are constructed is determined by taking into account the sequence and rate of earth moving and concrete placing operations for producing pavements.

The sequential sections are broken up into coverage sections, whose dimensions are determined from the following considerations.

In constructing sewers from concrete and reinforced concrete pipes 1 meter long (leading operation) on a monolithic concrete foundation, the length of the coverage sections should not be less than the daily [24 hours] output of the flow, in linear meters of sewer construction, multiplied by the number of days during which the concrete foundation ages. For example, if the aging time for the concrete foundation is 5 days and the daily productivity of the sewer construction brigade on a monolithic foundation is 100 linear meters, the coverage length will be 500 meters. When laying pipes on precast slab or soil foundation, the

dimensions of coverage sections used are not less than the three-shift output of sewer construction brigades.

Usually the length of coverage sections for the drainage operations flow is established by stakes or by sections from one access gulley to another.

Taking into account local conditions, the character of work and typical technological charts, a determination is made of the composition of brigades and teams of each element of the flow.

The composition of brigades and teams will be the following.

1. Team charged with digging an open ditch consists of 5 workers and the E-505 excavator. The output of such a team for a ditch depth up to 2 meters is up to 50 linear meters/shift.

2. Team charged with reinforcing the ditch slopes consists of 4 workers. The output of the team when covering with sod is 228 meters^2/ /shift, and in paving a single pavement, it is 50 meters^2.

3. Brigade charged with constructing outlet installations consists of 4 workers. The output is one installation per 6 shifts.

4. The brigade charged with digging of trenches consists of four teams:

the first team, consisting of 3 workers performs setting out work and installs the sight rails; the teams output is 200 linear meters/ /shift;

the second team consisting of 2 workers with a bulldozer removes and piles the topsoil at a 10-15 meter wide strip; the productivity of the team is 750 linear meters/shift;

the third shift consisting of 4 workers with an excavator digs and finishes the trenches; the teams productivity is 100 linear meters of trenches per shift;

the fourth team consisting of 3 workers braces the trenches with

standard bracings; the teams productivity is up to 100 linear meters//shift.

5. The team charged with construction of access gulleys, consisting of 5 workers. The productivity of the team is 1 gulley per shift when poured on location or 3 gulleys when working with precast slabs.

6. The team charged with placing of precase slab foundations and sewer pipes including the construction of elastic joints, consisting of 6 workers with a truck crane. The productivity of the team is 25 linear meters of finished sewer per shift.

7. The team charged with backfilling of trenches with soil, consisting of 3 workers with a bulldozer. The output is up to 200 linear meters/shift.

All these teams can be organized into integrated mechanized brigades of the flow:

first brigade charged with digging and bracing of trenches with a productivity of 100 linear meters of trenches per shift;

second mechanized brigade charged with sewer construction (leading operation) with a productivity of 25 linear meters/shift;

third brigade charged with backfilling of trenches with an output of 200 linear meters/shift.

Coordinates work of these brigades requires that they be correlated with respect to their output, for which reason the number of teams composing the leading brigade should be increased.

After the work of teams and brigades is coordinated, a schedule of flow operations in constructing the drainage system is drawn up.

Chapter 4

CONSTRUCTION OF SIMPLE PAVEMENTS

Simple airport pavements are constructed mainly from local construction materials (soil, sand, gravel, crushed stone, rocks, health slag, etc.). They are used as pavements in the construction of landing strips, and at permanent airports are used as foundations or base layers for permanent concrete or asphaltic concrete pavements.

Simple airport pavements include:

soil pavements with a selected optimal composition;

soil-macadam and soil-gravel;

untreated macadam, gravel and slag roads.

33. SURFACES FROM OPTIMAL SOIL MIXES

Land parcels selected for airport construction may have different soils with nonuniform (clay, loam, sand, etc.) bearing capacity. The physical and mechanical properties of local soil can be improved by changing their granulometric composition (optimal mixtures).

The composition of optimal soil mixtures depends on the climate features of the construction region. In dry regions the mixture requires a large amount of clay fractions, and a more substantial body with a small content of clay fractions is required in overmoist regions

Surfaces from optimal soil mixtures are constructed by mixing at the site and adding other soil.

The operations for constructing pavements from optimal soil mixtures include removal of topsoil and performance of earth moving operations, loosening and breaking up the local soil, introduction and dis-

tribution of admixtures, mixing the soil and admixtures, leveling out the mixture and grading of the surface and compacting the mixture.

TABLE 22

1 Район применения оптимальной смеси	2 Содержание фракций в оптимальной смеси, %		
	песчаных (2,0—0,05 мм) 3	пылеватых (0,05—0,005 мм) 4	глинистых (меньше 0,005 мм) 5
6 В районах нормального и недостаточного увлажнения	55—80	15—35	6—14
7 В районах избыточного увлажнения	65—85	10—30	3—10

1) Region in which the optimal mixture is used 2) content of fractions in the optimal mixture; 3) sand (2.0-0.05 mm); 4) dusty (0.05-0.005 mm); 5) clay (less than 0.005 mm); 6) in regions with normal and insufficient moisture; 7) in overmoist regions.

All the enumerated operations with respect to the local preparation of optimal soil mixtures should be mechanized in an integrated manner and should be performed by the flow method in the accepted technological sequence.

The topsoil is removed and the earth moving and preparatory work is performed using methods and means which were considered before.

The earth moving operations also include grading and leveling the surface in accordance with the design elevations. Before the admixture are added the soil is loosened and broken up in order to provide for their complete interaction with the soil being improved and for the formation of a uniform mixture.

Depending on the kind and state of soil, loosening may be performed by cultivators rippers, plows, scarifiers, rotary tillers and other equipment. The improved soil should, as a rule, be loosened to the design depth by a single passage of the machine over one track. Multiple passes of machines over the same path can result in excessive and nonumiform deepening, which will disturb the design ratios of the planned optimal mixture. The loosened soil should then be broken up and

pulverized by tooth-type or disk harrows to a degree such that it should not contain unbroken lumps larger than 5 mm. The soil should be broken up immediately after loosening, when it still retains its natural moisture. The soil admixtures which are introduced shouls also be broken up and pulverized.

After the soil being improved has been loosened and broken up, the admixture (of sand to clay soil or vice versa) is spread out in a uniform layer by the D-336 tractor-drawn distributor, in order to obtain the optimal sand and clay mixture.

The rate at which admixtures may be added per one pass of the distributor is from 0.04 to 2 meters^3 per 100 meters^2 of area.

The maximal spreading width is 2.4 meters and the time required for unloading material from one ZIL-585 dump truck is 3-4 minutes.

The admixtures thus added are mixed first by harrows and then finally by graders or rotary tillers until a homogeneous optimal mixture is obtained. Most desirable of mixing of local soil with admixtures are machines working on the principle of forced mixing, in which the mixture is imparted the speed with which the particles are displaced along the working elements, which exceeds manyfold the reciprocating velocity of the machine proper. The D-272 rotary tiller, which breaks up and mixes with admixtures a soil depth of up to 20 cm during 3-4 passes over the same trace in standard density soil, is such a machine.

Intermixing of soil with admixtures requires from 20 to 50 passes of a motor grader over the same trace, which does not result in high productivity and satisfactory quality of work.

After mixing, the mixture is leveled by a motor grader and compacted by rollers, first using light and then medium and heavy rollers on pneumatic tires, with the moisture close to optimal. The required moisture and density for rolling is controlled by the construction site

laboratory. All the machines work by the flow method on coverage sections 300-500 meters long and whose with is equal to the width of the surface. The soil mixing machine is the leading machine of the flow. The need for all auxiliary machines is calculated on the basis of the productivity of the leading machine.

The integrated set of machines recommended for working with the rotary tiller is as follows:

Heavy motor grader .	1	D-336 distributor	2
Rotary tiller D-272	2 (leading machine)	Self-propelled rollers . .	2
		The D-263 drawn roller . .	1
The D-162 ripper	1	The PM-8 watering machine .	1
Harrows	1 set		

The productivity of this set is up to 2500 meters^2/shift.

In all cases the rotary tiller should work in the same gear in order to ensure uniform breaking up and intermixing of the soil with the admixtures.

34. SOIL-MACDAM AND SOIL-GRAVEL PAVEMENTS AND FOUNDATIONS

The stability of soil macadam and soil-gravel pavements depends on the rock and soil content of the mixture and on the grain-size distribution. The composition of mixtures is chosen from graphs and tables of optimal mixtures, which approximately corresponds to a content of from 50 to 70% of stone base material. Local soil is used for filling voids and pores in thestone material.

Depending on the dimensions of the largest stone fraction, the soil-gravel and soil-macadam mixtures are divided into:

coarse grain with the largest particle size up to 50 mm;

medium grain with the largest particle size up to 25 mm;

fine grain with the largest particle size up to 15 mm.

The compositions of soil-gravel and soil-macadam mixtures used in

TABLE 23

Смеси 1	Количество частиц, проходящих через сита с отверстиями, мм, % по весу частиц 2											
	80	40	25	15	5	2	1	0.5	0.25	0.15	0.074	0.005
Для верхнего слоя покрытия 3												
4 Крупнозернистые	—	100	85	70	47	2[illegible]	22	15	10	8	7	7
	—	—	95	8[illegible]	6[illegible]	52	4[illegible]	35	23	25	27	18
5 Среднезернистые	—	—	100	81	57	3[illegible]	2[illegible]	18	13	10	8	8
	—	—	—	95	85	70	5[illegible]	4[illegible]	35	25	23	21
6 Мелкозернистые	—	—	—	100	63	40	30	22	15	12	10	11
	—	—	—	—	9[illegible]	75	60	45	36	30	25	22
7 Грунтовые	—	—	—	—	—	100	70	48	3[illegible]	21	16	13
	—	—	—	—	—	—	8[illegible]	70	60	50	40	35
8 Только для нижнего слоя покрытий												
4 Крупнозернистые	100	—	75	80	35	27	—	—	10	—	5	4
	—	—	85	80	65	5[illegible]	—	—	3[illegible]	—	18	17
»	—	100	80	57	30	15	1[illegible]	5	3	1	0	0
	—	—	85	70	41	2[illegible]	22	15	10	8	7	7
»	100	—	55	37	[illegible]	[illegible]	—	—	0	—	0	0
	—	—	75	60	3[illegible]	2[illegible]	—	—	10	—	5	4
5 Среднезернистые	—	—	100	70	35	18	12	6	4	2	0	0
	—	—	—	80	5[illegible]	3[illegible]	2[illegible]	1[illegible]	13	10	8	8
6 Мелкозернистые	—	—	—	100	5[illegible]	2[illegible]	15	10	5	2	0	0
	—	—	—	—	63	4[illegible]	30	22	13	12	10	10

Note. The content of clay (particles finer than 0.005 mm) in soil-macadam and soil-gravel mixtures for the upper surface layer should not exceed 3%, and for the lower layer it should not exceed 5%.

1) Mixtures; 2) number of particles passing through sieves with holes, mm, % of particle weight; 3) for the upper pavement layer; 4) coarse grain; 5) medium grain; 6) fine grain; 7) soil; 8) only for the lower surface layer.

pavement construction are given in Table 23.

Construction of soil-macadam and soil-gravel pavements by mixing on location consists of the same operations and is performed by the set of machines as the construction of soil surfaces from optimal mixtures. The feature of the former process is the fact that after the soil-macadam or soil-gravel mixture in the construction of temporary pavements was finish graded and rolled, it is necessary to additionally spread on the surface pulverized topsoil in the amount of 1-2 meters^3 per 100 meters^2 of the pavement area, and then sow sod-producing grass at a higher seeding rate (300-400 kg/hectare). If the soil-gravel and soil-macadam pavements are used as the foundation or bass layers,

then their surface is not treated with topsoil and sod-producing grass is not sowed.

Soil pavements from optimal sand and clay mixtures, soil-gravel and soil-macadam pavements are constructed without artificial foundations and without additional structural layers, directly on the existing soil surface.

35. MACADAM PAVEMENTS

Pavements from uniformly crushed stone rolled in the moist state with wedging also belong to simple pavements. The rock pieces are bound by internal friction of the crushed rock and by the binding action of stone dust.

The disadvantage of macadam surfaces is the fact that they are dust producing, nonmoisture resistant and are rapidly broken up by the loads of modern aircraft. These are transitional pavement sand are widely used as foundations for improved and permanent pavements.

Macadam pavements are constructed directly on the soil or on a base of sand, gravel or slag. The pavement thickness depends on the intensity and character of loads. Single layer macadam pavements are constructed with a thickness of up to 18 cm, and twin layer pavements may be thicker than 18 cm; here the thickness of the upper layer should not be less than 6-8 cm.

The crushed stone used for pavement construction is subdivided by size into

Coarse, with fraction size	60-70 mm
Medium " " "	60-35 "
Fine " " "	35-25 "
Chippings " " "	25-15 "
Stone fines with fraction size	15- 5
Siftings " " "	finer than 5 mm

The crushed stone should satisfy the following requirements: be

close to cubical in shape; contain not more than 25% by weight of flat (lammerlar) shaped grains; have a uniform strength and have an ultimate strength of not less than 300 kg/cm^2 when fully saturated with water; should withstand up to 25 cycles in frost resistance tests; the maximum size of its particles should not exceed one half of the pavement thickness; should not contain more than 2% by weight of clay and dust particles, clay lumps, loam and other admixtures.

Before the construction of a macadam pavement starts, the base course or the trench bottom should be completely graded.

The pavement is constructed in strips not less than 10-15 meters wide by the longitudinal or longitudinal section method. Supports made of girders are placed along the edges of the strip at the begining of work and at one side in subsequent construction of strips, in order to prevent the crushed stone from spreading out on rolling. The height of the girders should be equal to the thickness of the layer being constructed in the compacted state. After compacting the girders are moved over to the following coverage sections or strips.

Coarse crushed stone (for constructing the lower layer of a twin-layer pavement) is transported to the prepared foundation by dump trucks and are spread out in a layer of the required thickness.

The crushed stone is dumped into piles directly in the trench or onto the foundation from dump trucks from the side fo the finished pavement or finished crushed stone fill.

In order to have enough crushed stone for obtaining the specified pavement thickness, its amount, needed for the strip being constructed is determined from the formula

$$Q = BhK_y$$

where B is the strip width, meters; h is the design thickness of macadam in the solid state, meters; and K_u is the coefficient of macadam

compaction, equal to 1.3-1.4.

The unloaded crushed stone is leveled by a bulldozer or motor grader over the foundation over the entire width of the strip. The heavy motor grader can be equipped with a blade for the leveling operation (changable equipment).

The crushed stone can be spread out over the foundation or trench by the D-337 self-powered macadam spreader or asphalt spreader, which not only spread but partially compact the layer being laid. Before final compacting the macadam, its surface should be graded by a motor grader. The dumped and spreaded macadam should not be left without compacting for more than one day.

In the process of rolling of the macadam layer first individual stone particles are brought closer together and then compacting takes place with filling of voids with stone fines. The entire process of rolling of a single-layer macadam pavement can be subdivided into four stages.

In the first stage the spread crushed stone is rolled by light motor rollers weighing 5-6 tons at a speed of not more than 1.5-2 kilometers/hour. The rolling in this stage is performed from the edges toward the middle of the filled strip without watering until no waves are formed ahead of the roller's rolls and until the roller ceases to produce a noticeable trace. This stage requires 6-10 passes of the roller over the same trace.

In the second stage the working macadam is finish compacted, which gives a hard, stable skeleton. In this compaction stage use is made of heavy motor rollers weighing up to 12 tons and the macadam surface is watered. The speed at which the rollers move should not exceed 2 kilometers/hour.

The external signs showing that the compacting in the second rol-

ling stage is sufficient are the following: the stone particles do not move; the rollers on passing, and a stone piece of the rollers is crushed. Final control of the density is performed by sampling by the laboratory.

During the second rolling stage care should be taken in observing the aforementioned signs of complete compacting of the macadam, since eccessive rolling results in "overrolling" in which the fractions are rounded off and the rolled layer is totally destroyed. The "overroling" is corrected by replacing the rounded off stone particles. The number of passes over the same trace depends on the weight of the roller, the strength of the crushed stone, the thickness fo the rolled layer and as an average it comprises 12-35. If it is the base course of a two-layer pavement which is constructed, then the operation following the second rolling stage is the dumping of the basic crushed stone for the upper layer, leveling it and compacting, also in two stages.

The third rolling is performed for obtaining a dense macadam core by introducing chippings into the upper pavement layer. Chippings are dumped in the amount of up to 1 meter^3 per 100 meters^2 of area. The spread chippings should, before rolling, be thoroughly pushed into the voids by mechanical brushes or manually, by metal brooms. After the chippings have been spread they are rolled by medium and heavy motor rollers with sprinkling with an average of 6-8 passes over the same trace.

The fourth rolling stage is performed only in constructing macadam pavements for creating a protective cementing layer by spilling, using a spreader, of stone fines or screenings from weak limestone in amounts up to 0.80 meters^3 per 100 meters^2 of area. Rolling in this case is performed by medium and heavy rollers with sprinkling. The average number of roller passes is 4-6 over the same trace.

A two-layer pavement is compacted by layers. The lower layer is rolled using void filling material and the upper layer is rolled as a single-layer pavement.

The approximate water consumption in sprinkling on compacting is from 15 to 50 liters per 1 meter^2 of compacted area. A sign showing that the fill is sufficiently moist is the fact that the lower faces of the uppermost layer of stone particles are wet.

This ends the construction of a macadam pavement.

The following set of machines can be used in constructing macadam pavements:

Dump trucks for bringing in of materials	as calculated
Bulldozer or crushed stone spreader	1
Motor grader	1
Sprinkling machine	1
Motor rollers	2
Chippings spreader	2

The productivity of this intergrated team is up to 1000 meters^2 of pavement per shift.

36. GRAVEL PAVEMENTS

Gravel pavements are constructed from local sand and gravel mixtures which are not subjected to any complicated processing. It is best to use quarry gravel, which contains a sufficient amount of sand and clay dust particles for filling all the voids on rolling and for obtaining a dense and strong pavement.

If river, sea or lake gravel are used as the local material, then the optimal gravel mixture is compounded artificially by adding sand, clay and dust particles.

The optimal gravel mixture is chosen on the basis of special graphs and tables (Table 24).

The greatest gravel size in the mixture should not exceed half of

TABLE 24

1 № смеси	2 Количество частиц, прошедших через сито с отверстиями, мм, % по весу							3 Свойства смеси, прошедшей через сито с отверстиями 0,5 мм	
	40	25	15	5	2	0,5	0,05	4 предел текучести	5 число пластичности
1	100	65—85	35—50	21—35	13—25	5—15	3—5	6 Не более 25	4—6
2	100	25—45	21—35	15—27	10—15	5—10	1—3	7 То же	3-4
3	90—100	55—85	35—75	23—60	13—50	10—30	0—3	»	8 До 3
4	—	80—100	60—90	30—70	20—55	15—40	0—3	»	До 3

1) Mixture number; 2) number of particles passing through a sieve with holes, in mm, % by weight; 3) properties of mixture which has passed through a sieve with 0.5 mm holes; 4) yield point; 5) plasticity index; 6) not more than 25; 7) same as above; 8) up to.

the design thickness of the pavement. The choice of the gravel mixture composition depends on the pavement thickness and on the size of quarry gravel material available near the construction site. The more preferencial in the choice of quarries are compositions No. 1, 2 and 3, since composition No. 4 is expedient only in a region with a dry climate and favorable hydrogeologic conditions. The content of particles finer than 0.05 mm in the mixture should at the lower limit in regions with excessive surface moisture and should be at the upper limit in regions with a dry climate.

The gravel mass is laid on the natural or reinforced foundation in one or two layers. The amount of and thickness of layers depend on the intensity of aircraft-produced loads and are determined by calculations. Single layer pavements are made up to 16 cm thick and twin layer pavements are made thicker than 16 cm.

The disadvantage of gravel pavements is the fact that they are softened by precipitation and become dusty in dry weather. They are transitional pavements and are most frequently used as base courses for temporary prefabricated improved and permanent pavements.

These pavements are constructed in sections of not less than 300

meters over the entire width of runways or by 10-15 meters wide strips. Before the pavement construction starts preparatory operations are performed. The quality of the road bed is checked and the operations are set out by using a leveling instrument for placing every 20 meters of reference marks, showing the required thickness of each construction layer taking into account the coefficients of loosening of the gravel material.

The gravel material is delivered to the road bed by dump trucks first for the lower layer. It is bess that the trucks be made to travel over an already constructed pavement or foundation, or over the finished leveled mixture. It is prohibited to drive over an overmoist pavement bed or over a sand foundation.

The distances between the dumping points for the mixture is determined by calculations by the formula

$$l = \frac{q}{BhK_y},$$

where l is the distance between the centers of piles, meters; q is the volume of material hauled by the dump truck in one trip, meters^3; B is the coverage section width, meters; h is the thickness of the gravel material layer in the solid state, meters; and K_u is the gravel compaction coefficient.

The piles are leveled out and the material thus spread is graded by a heavy motor grader with mounted equipment consisting of a bulldozer blade.

First the gravel material is compacted by light motor or tractor drawn rollers weighing 5 tons by 5-7 passes over the same trace. The final rolling is performed by heavy motor rollers on pneumatic tires in 8-10 passes. The rolling is stopped after obtaining a density at which no impression is formed when a heavy roller passes through it. If

the material's moisture is below optimal, it is sprinkled during rolling. Surface undulations which form on rolling are eliminated by supplemental grading of the surface by a motor grader. If the surface has two layers, then the second layer is constructed in the same manner as the first, after the first has been rolled.

It is rolled from the strip's edge to its middle with overlapping of traces by approximately 1/3 of the width of the previous rolling pass.

The number of roller passes depends on the composition of the gravel mixture, the type and weight of rollers being used. A normally rolled pavement is characterized by the absence of noticeable waves ahead of the roll of a 8-10 ton motor roller.

The following set of machines can be used in constructing a gravel pavement:

Dumping trucks	as calculated
Motor grader	1
Motor rollers	2
Tractor drawn roller .	1
Bulldozer	1
Sprinkling machine . .	1

The productivity of this set is up to 2000 meters^2 of pavement pershift.

37. SLAG PAVEMENTS AND FOUNDATIONS

Many regions of our country posses large stockpiles of metallurgical slag, which are suitable for construction of airport foundations and pavements. By the methods by which they are obtained, metallurgical slag types are divided into blast furnace, open hearth furnace, copper melting, steel smelting, cupola slag, etc.

Depending on their chemical composition, the slags discharged by a blast furnace are divided into basic and acid slag.

The basic slag group consists of those in which the ratio of the total percentage content (by weight) of lime and magnesium CaO and MgO to the sum of silica and alumina $SiO_2 + Al_2O_3$ comprises not less than unity, i.e.,

$$M = \frac{CaO + MgO}{SiO_2 + Al_2O_3} > 1.$$

The acid slag group embraces slag types with $M < 1$.

Pavements (foundations) are constructed from crushed slag sorted out by fractions, laid in conformance with requirements put to the selection of fractions and the voids filling principle.

The basic slag is characterized externally by a porous and rough grayish surface. This slag, when compacted by heavy rollers with simultaneous sprinkling of water, posses their own binding properties due to the cementing property of the slag flour. They can be used for constructing strong monolithic rigid foundations and pavements.

Slag pavements constructed without being treated by binders do not have a long service life. They become very dusty under the action of aircraft loads and break up rapidly. Foundations for improved and permanent pavements can be constructed from slag. Such foundations increase their strength with time, and by the service life even exceed macadam foundations made from natural medium strength stone.

Slag is especially conveniently used in regions which lack natural stone deposits. Experience in the construction of roads and airports shows that basic slag can be successfully used for constructing pavements treated by organic binders by the enthod of mixing at the site.

Acid slag can be successfully used in constructing pavements and foundations both treated by organic binders as well as untreated.

Pavements and foundations should be constructed from basic and

acid slag which laid around in the dump not less than two years. The slag should not contain foreign impurities and chemically nonbinding metal and should resist all kinds of chemical disintegration.

Blast furnace basic and acid slag are a byproduct in the smelting of pig iron from iron ore.

Open hearth slag, as blast furnace slag, is divided into basic and acid. A feature of the open hearth slag is the fact that it is difficult to process without being crushed first, since it lays around in the waste piles in the form of individual pieces, as well as in the form of large stone up to 3-5 meters^3 in volume. The ultimate strength of blast furnace and open hearth crushed slag in compression varies between the limits of 25 to 400 kg/cm^2 for porous and from 400 to 1200 kg/cm^2 for crystallic slag.

Construction of pavements and foundations from crushed slag does not at all differ from the technology of operations in constructing macadam pavements and foundations from crushed stone.

Gravel, macadam and slag pavements can be constructed in the winter time. In this case the runway bed should be constructed and carefully graded before the onset of cold weather. The foundation material is rolled by heavy motor rollers without sprinkling. Then in the spring after thawing, slight additional rolling of the pavement is required.

38. CONTROLLING THE QUALITY OF WORK AND RECEIVING IT

Quality control and acceptance of operations concerned with constructing simple airport pavements provides for checking of:

the quality of materials used and their conformance, by quantity and composition, to the design specifications, to technical specifications and to rules for performance of operations (checked by data of laboratory tests);

degree of pavement compaction;

conformance of the elevations of the longitudinal and transverse profiles to design specifications (checked by leveling of not less than 10% of the entire area);

thcikness of pavement by making not less than two holes per 400 meters^2 of finished pavement;

the width, length and level of the surface by check measurements.

The following deviations from the design dimensions are permissible in constructing simple airport pavements:

up to 5% but not more than 2 cm with repect to the pavement thickness;

up to 10 cm with respect to the pavement width.

The deviation of grades form design specifications should not exceed $\pm$ 0.002.

The accepted work should be formalized by an act after all the exposed defects have been eliminated.

The surface level is checked by a three-meter ranging rod. The gaps between the pavement surface and the ranging rod should not exceed 5 mm.

Chapter 5

CONSTRUCTION OF IMPROVED PAVEMENTS

Pavements which are constructed from local building materials (soil, gravel, crushed stone, etc.) by treating with organic (bitumen and tar) or mineral (cement and lime) binders are classified as improved. The improved pavements are characterized by their high strength and decreased wear in comparison with simple pavements. In addition, they are not dust producing, water resistant and water tight and can be used as foundations for permanent pavements.

Cement treated soil pavements, soil macadam, gravel and slag pavements treated by organic binders are referred to as improved pavements.

39. CONSTRUCTION OF SOIL CEMENT PAVEMENTS AND FOUNDATIONS

During the last few years extensive work was performed in the USSR for adapting to the practice fo airport construction of soil cement pavements and foundations.

Cement introduced into soil exerts a twofold effect on it: firstly, the soil particles are cemented, which imparts binding and strength properties to the soil; secondly, the cement, acting on the soil as a chemical additive, radically improves its physical and mechanical properties (stickiness, plasticity and water saturation disappear). Soil-gravel and sand-gravel optimal mixtures can also be reinforced by cement.

The construction of soil cement pavements and foundations is characterized by its simplicity and by feasibility of integrated mechanization of the construction work.

Soil cement is an economically advantageous construction material. only cement, which comprises 6-18% of the weight of the treated soil, is brought in.

Soil cement pavements are by a factor of 2 cheaper than stone pavement sand their strength is entirely sufficient for the present-time aircraft loads.

The carrying capacity of soil cement increases as the percentage content of the cement additives increases. Her the amount of cement needed for imparting the necessary strength to the soil depends on the activity of the cement and on the soil.

When reinforcing optimum composition soils, the cement consumption is decreased. Cement treatment of soil containing alkalies and acids is forbidden.

The thickness of single layer soil cement pavements is determined by calculations and as an average comprises 25 cm.

The following main technological requirements must be satisfied in constructing soil cement pavements and foundations.

The soil should be pulverized to the necessary degree. Special care should be taken in batching of cement in order that it be distributed uniformly in the reinforced soil, a check should be kept on the moistening of the dry mixed soil cement mixture up to optimal moisture and on preserving this moisture during its compaction.

The soil and cement should be uniformly mixed, the finished mix should be compacted to the required density with strict conformance to the scheduled termination of condensing.

The finished pavement should be provided with proper curing.

The soil should be mixed with cement at air temperatures not below $+5^{\circ}$.

Soil cement pavements and foundations are constructed by mixing at

the site or in stationary installations.

The on-the-site mixing method is the main, most productive and economical method and consists of the following operations;

removal of topsoil and grading of the section;

loosening andbreaking up the soil;

introducing into the soil of additives for obtaining an optimal soil mixture and intermixing of the soil with the additives;

spreading the cement and intermixing it with the soil in the dry state;

moistening the mix and intermixing it in the moist state;

compacting the mix;

curing the pavement;

constructing a protective layer by surface treatment.

The pavement quality depends to a considerable extent on the proper performance of all the enumerated operations, which should be executed continuously with conformance of the technological sequence.

Pavements are constructed in sections which should be finished within a shift totally, without disrupting the production flow. The time elapsed between the instant the cement is introduced into the soil and the termination of compacting the mix should not exceed 5 hours.

Cement whose brand is not lower than 400 is spread by the D-343A spreader on the loosened and pulverized soil of optimal composition. The cement consuption for sand and gravel soil comprises 5-7%, for sand loam soil it is 8-10% and for dusty and argillaceous soil it is 12-16% of the weight of the treated soil. It is recommended that bitumen or tar emulsion should be introduced into the mix in order to increase waterresistance and watertightness of the soil-cement pavement (foundation) and also to decrease the cement consumption rate.

The D-343A spreader is used to get the cement into the soil to a

depth of up to 80 mm, which prevents its being blown away by winds. The capacity of the cement spreader hopper is 2.3 meters^3; and the cement spreading rate is from 15 to 50 kg/meter^2 per one pass; the spreader productivity is up to 50 tons per hour. The spreader's hopper is loaded by a cement truck with pneumatic dumping equipment.

The soil moisture during the spreading of cement should be within the limits of that which is optimal for the given soil.

After being spread, the cement id intermixed by the D-272 rotary tiller with soil (in the dry state) to the design depth until a mixture which is uniform in color is obtained. In order to ensure intermixing uniformity, the mixing rate should be constant. Only 2-3 passes of the tiller over the same trace are required for mixing soil with cement in the dry state.

The intermixing of soil with the cement is the leading operation. After a uniform mixture is obtained it is sprinkled by sprinkling machines and again mixed by the rotary tiller. The water consumption depends on the natural moisture content of the soil.

After intermixing, the surface is graded by a light motor grader and thoroughly compacted to the design density.

Depending on the layer thickness, the pavement can be compacted by smooth rollers. When the compacted sections contain undulated parts, the surface is leveled out by a motor grader during and after the rolling, with the cut off soil-cement removed from the higher lying points moved out from the construction site.

The recommended set of machines for reinforcing soil by cement is as follows:

Heavy motor grader	1	Self-propelled roller on pneumatic	1
Light motor grader	1	tires	1
D-272 rotary tiller (leading machine)	2	Motor rollers	2
		Sprinkling machine	1-2

D-343A cement spreader	1	Cement truck	1-2
		Scarifiers and plows	1 set

The productivity of this set of machines id up to 2000 meters^2/ shift.

<u>The D-282 soil mixer</u> ensures integrated mechanization of operations in cement enriching of the soil. The machine consists of two independent units dtawn by the DT-54 tractor interconnected by the sequence of the technological process of construction and by a set of special containers for hauling the cement and loading into the hopper of the first unit. The container capacity is 1500 kg of cement.

The first, D-282-I, unit loosens and breaks up the soil and mixes it with cement in the dry state. The width of the treated strip is 2.2 meters, the depth is up to 0.2 meters and the cement laying rate is from 10 to 60 kg/cm^2. The cement is supplied from containers to the batching hopper by truck cranes from moving trucks. The productivity of the first unit is 800 meters^2/hour.

Before the first unit begins to work in hard soil, the dense soil must be loosened by heavy rippers or plows to the design depth. All large stones, roots and other foreign objects, which could damage the working elements of the machine must be removed during the loosening operation.

The first pass of the unit is made in the direction of a stretched line which shows the path to be followed by the external edge of the right crawler of the tractor pulling the first unit of the machine. The successive rows are marked by a line so that the working elements of the first unit on passign should overlap not less than by 10 cm the previously treated adjoining section. Care should be taken during the work of the first unit after the amount of cement in the hopper, and to reload it when less than 500 kg of cement is left (the hopper capac-

ity is 300 kg). I less cement is left in the hopper, its spreading over the width of the section will not be uniform. As the section is treated by the first unit, the staking pegs are removed to avoid their falling into the pavement.

The second, D-282-II, unit moves after the first and additionally breaks up the soil, again intermixes it with cement, sprinkles it with water and the intermixes the mixture in the moist state.

The second unit moves after the first over the tracks left over by the first unit, so that the external edge of the left crawler of its tractor move in the middle of the tracks of the first unit's wheels and the right crawler overlap by 1/3 of its width the noncompacted middle part of the section. The section is treated by the second unit without stopping for picking up water. all forced stops result in overmoisting the mixture and making its compacting more difficult.

The D-282 soil mixer operates continuously. The units are supplied with cement and water in motion. Each unit is drawn by a DT-54 tractor equipped with a speed reducer making it possible to lower the speed to 0.36-0.8 kilometers/hour. The following are the working speeds of the I and II units in constructing 15-20 cm thick pavements; on clay soils 235 meters/hour, argillaceous soils - 300 meters/hour and 484 meters/hour on sandy loam soil.

The soil is mixed with cement by the D-282 soil mixer by a team equipped with the following pieces of equipment:

The D-282 soil mixer	1 set
K-32 or K-51 truck cranes (two for loading and two for unloading)	4
ZIL-150 side-panel trucks for hauling containers cement over a distance of up 3 kilmeters	8
Tank trucks for supplying water having a capacity of up to 15 meters^3 for a hauling distance of up to 3 kilometers	2

Light roller on pneumatic tires or drawn smooth rollers weighing 5-6 tons	2
Heavy rollers on pneumatic tires	2
Smooth motor rollers weighing up to 10 tons	2
Light motor grader	1
Self-propelled asphalt spreader	1
D-336 screenigs spreader	1
D-162 heavy ripper	1
Sprinkling machine for curing the pavement	1
Drawn mechanical highway broom	1

The productivity of this integrated mechanized team is up to 5600 meters^2/shift.

The main disadvantage of the D-282 soil mixer is the fact that it does not perform the entire integrated sequence fo operations. After the second unit of the machine has passed, a considerable amount of time is spent in compacting and finish grading at the instant when the soil sets with the cement. In addition, it requires adherence to strict operational schedules and a large number of various auxiliary machines.

The D-391 self-propelled, single pass, multirotor soil mixer with pneumatic tires, which loosens and breaks up the soil, measures out and spreads the cement and water, intermixes the soil and cement in the dry and moist states, and also partially compacts the mixture, has been assimilated in 1958. The working speed of the D-391 is up to 0.86 kilometers/hour. The width of the strip being enriched is 2.4 meters and the depth up to 25 cm. The cement spreading rate is from 6 to 52 liters/meters^2. The cement is supplied and loaded into the hopper by a cement truck while in motion and the water is brought in by a tank truck. Finish compacting of the mixture is performed by rollers. The time from the cement application to final finishing and compacting does not exceed 1 hour while in the case of the D-282 machine it exceeds 5 hours. After compacting and finishing the surface, suitable conditions

for formation of the pavement are provided for by curing, as in the case of a concrete pavement.

After the cement sets, the pavement surface becomes rough and requires surface treatment by organic binders for creating a wearresistant and watertight layer.

It is gest to perform the surface treatment during the pavement curing time, in order to maintain the mixture at its greatest moisture content, but together with this, damage to the pavement by the passing of machines should not be permitted.

Surface treatment is performed by spreading over the pavement surface of thinned bitumen in the amount of 1.5-2 liters/meter^2 with subsequent spreading of sand or screenings in the amount of 1 meter^3 per 100 meters^2 of area. When the soil-cement acquires the necessary strength, the surface is rolled by 2-3 passes over the same trace of light rollers.

Surface treatment is not performed in the construction of soil-cement foundations.

The D-391 machine is serviced by the S-386 cement truck, by the D-351 truck tank for water, by the D-365 and D-399 self-propelled rollers, by the D-336 spreader, the D-164A self-propelled asphalt spreader, a light motor grader and a ripper, in hard soil. The productivity of this set of machines is up to 15,000 meters^2/shift.

40. REINFORCING SOIL PAVEMENTS AND FOUNDATIONS BY ORGANIC BINDERS USING THE METHODS OF MIXING AT THE SITE AND IN INSTALLATIONS

Soil pavements made from optimal mixtures flow when made overmoist and become unpassable, and in hot weather they become dusty and break up. If these simple pavements are treated by organic binders, they become stronger, dustless, watertight, elastic and can ensure year round take offs and landings. Soil reinforeced by organic binders are

also used as foundations for improved and permanent pavements.

Soil can be treated by binders by mixing at the site or in special portable mixers without heating and drying the material being reinforced. The on-the-site mixing method is the more widely used and simple. The main requirement in treating local soil consists in the fact that their composition be close to optimal and that they should not contain harmful impurities of salts, acids and alkalies, which have a damaging effect on the pavement being produced. Liquid highway bitumen of various brands are used as binders in treating of local soil, soil-gravel and soil-macadam mixtures by the on-the-site mixing method.

The binder brand and the rate of application is determined depending on the kind of material being reinforced and on the climate at the construction site.

More cohesive bitumen brands should be used in regions with a hot and dry climate, with the class A fluid or shale bitumen recommended for regions with a large amount of precipitation. Approximate consumption rates for thinned bitumen for reinforcing mineral materials are given in Table 25.

Bitumen treated soil pavements are constructed in a single layer for a thickness of up to 15 cm and in two layer when the thickness exceeds 15 cm. The coverage sections is taken so that the self-propelled asphalt spreader, when spreading the binder should, in a single pass or an integral number of passes, relieve itself entirely of the binder when the application rate is not more than 3-4 kg/meter^2. The coverage section width is equal to the entire runway or taxiway width.

No special distances are established for turning the machines around, and sections up to 25 meters long where machines are turned about are graded and compacted for the second time, after the work

TABLE 25

1 Укрепляемые минеральные материалы	Рабочая влажность, % от веса минерального материала 2	3 Ориентировочные нормы расхода жидкого битума (безводного)	
		4 % от веса минерального материала	кг/м³ смеси в плотном теле 5
6 Грунтогравийные и грунтощебеночные смеси	3—5	4—7	80—140
7 Супеси с числом пластичности 3—7	4—7	5—8	100—156
8 Суглинки с числом пластичности 7—12	6—10	8—12	155—200
9 Суглинки с числом пластичности 12—17	8—10	12—14	200—250

1) Reinforced mineral materials; 2) working moisture, in % of the weight of the mineral material; 3) approximate consumption rates for liquid bitumen (waterless); 4) % of the weight of the mineral material; 5) kg/meters^3 of the mixture in the solid state; 6) soil-gravel and soil-crushed stone mixtures; 7) sand loam with a plasticity index of 3-7; 8) argillaceous soil with a plasticity index of 7-12; 9) argillaceous soil with a plasticity index of 12-17.

in the adjacent coverage section is ended, over the entire pavement width.

Construction of a single layer pavement by the on-the-site mixing method consists of preparatory, main and finishing operations.

Preparatory operations include earth moving, loosening and breaking up the soil to the design depth, introduction of additives calculated for obtaining an optimal soil mixture.

The following are the main operations: sprinkling the soil, if necessary, introduction of binder into the soil, mixing the soil with the binder to obtain a homogeneous mixture and compacting the mixture.

Finishing operations consist of grading and surface treatment of the pavement.

The quality of pavement thus constructed depends on the scheduled and thorough performance of the aforementioned operations and on continuity of the technological process in the flow.

The greatest effect of soil treatment by binders is obtained when its moisture is optimal. The moisture promotes better breaking up of

the soil skeleton, uniform spreading of the binder in the soil on mixing, and in compacting the treated mixture it ensures the greatest density of the pavement. When the treated material is optimally moist, the time required for mixing it is decreased. The soil is made moist by sprinkling machines.

After being sprinkled the soil is mixed by harrows in the wet state by 2-3 passes over the same trace. The field laboratory controls the required moisture.

Binders can be applied to the loosened soil by several passes of the D-397 drawn asphalt spreader hitched to the D-351 large capacity truck tank or by a special self-propelled asphalt spreader train. The rate of application by the enumerated machines per one pass varies within wide limits (from 0.5 to 7 liters/meters^2). The higher application rate of not more than 7 liters/meter^2 is used in the first pass while not more than 3 liters/meter^2 is used in the subsequent passes.

The self-propelled asphalt spreaders apply bitumen, tar and emulsions in the cold as well as in the hot state. The binders can also be applied by the D-445 rotary tiller through a special delivery system mounted on the tiller.

The working temperature of the bitumen being spread depends on the bitumen brand and on the air temperature during application, which should be not lower than +15^o. The first application of binder is made into moist, loosened and broken up soil with a strip width of up to 7 meters. Immediately after the first application, harrows or cultivators ar used for mixing the soil with the binder in order to made it possible for it to penetrate into the soil being treated to the design depth. After each successive application the soil is intermixed by 2-3 harrow passes, and after the last application of binder the soil is finish mixed by a rotary tiller or by a motor grader over the entire

width of the section. This requires 3-4 passes of the tiller or 80-100 passes of the motor grader over the same trace (mixing with motor graders does not ensure high mixing quality).

The mixing of the mixture is terminated when the soil being treated acquires a uniform dark-brownish color, and when the mixture is pressed in the palm a lump is formed which falls apart easily when waves created by motor grader passes become fluid.

The D-391 self-propelled soil mixer which should be serviced by the D-351 tank truck or the D-164A self-propelled asphalt spreader can be used for intermixing the soil with organic binders. The D-391 machine is an integrated unit and performs all the operations of black soil pavement construction in a single pass.

After final mixing the mixture is rough graded by 2-3 passes of a motor grader over the same trace and then it is rolled.

First the mixture is compacted by light, and then by medium and heavy motor rollers or by self-propelled rollers on pneumatic tires.

Attention is paid during rolling to the evenness of the pavement surface and to its density. Compacting is performed from the edges toward the middle for a crown cross section and from the lower side for a pavement cross section sloping to one side, according to the shuttle scheme. When constructing a single layer foundation, this terminates the work.

If the foundation or pavement is double layered, then the aforementioned processes for constructing the lower layer are repeated with addition of processes for transporting soil for the upper layer and of surface treatment in the case of pavement construction.

A disadvantage in the use of the above set of machines for constructing the upper layer is the fact that the lower layer can be deformed by their passing, and the intactness of the lower compacted lay-

er can be disturbed in intermixing the upper layer by the rotary tiller or motor grader. In this case it is advantageous and rational to use a special set of machines for constructing the first and second layers. The basic machines of this set consist of the portable D-370 mixer with the D-371 or D-415 tractor-loader (Fig. 75), which continuously perform the entire mixture preparing process. The D-371 loader supplies soil from the pile to the hopper of the D-370 mixer.

The D-415 loader is unified with the working speeds of the D-150A asphalt spreader, which makes it possible to include into the set of machines the D-150B asphalt spreader for spreading and compacting the mixture. If necessary, when the soil is overmoist, the D-415 loader can tow the D-381 drying drum and supply to it soil from the pile for drying and warming up.

In constructing a twin-layer pavement the normal operation of the set of D-370 and D-371 machines is ensured by supplying the section with soil for the lower layer brought in from the quarry by dump trucks which is then laid by a motor grader in a continuous windrow with a uniform cross section of up to 0.4 meters^2 over the entire length. The dimension of the windrow bottom should not exceed 2.5 meters, in order to make it possible to cover the entire material by the scraper bucket of the D-371 or D-415 loader.

Additives for obtaining optimal mixtures can be introduced into these soil windrows with subsequent intermixing by a rotary tiller of motor grader.

The D-371 or D-415 loader raises the soil from the windrow and loads it into the hopper of the D-370 mixer. Then (in the D-370 mixer) the soil passes through a proportioning device into the mixing unit and, after being mixed there with hot bitumen, is supplied through a trough to the D-150B spreader. The bitumen is supplied to the service tank of the operating mixer by the asphalt spreader which moves side by side with the mixer.

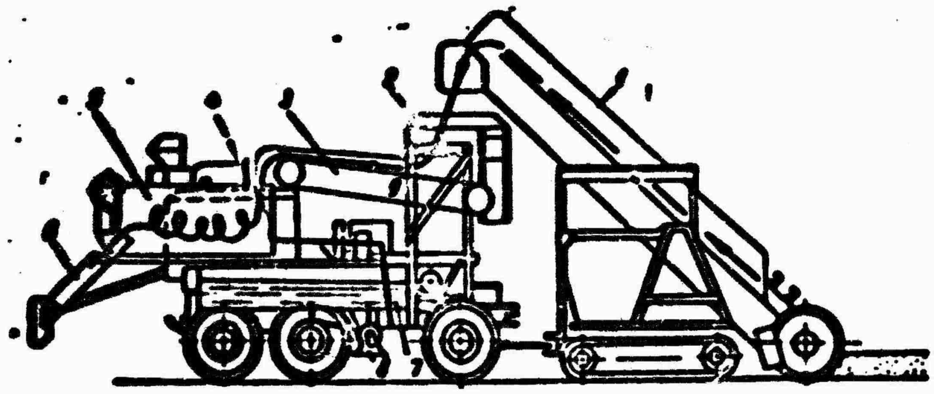


Fig. 75. Technological scheme of the operation of the D-370 mixer. 1) D-371 (D-415) loader; 2) receiving hopper of the mixer; 3) slat feed conveyer; 4) spreading pipe; 5) twin-roller mixer; 6) unloading trough; 7) service tank for binder with 2650 liters capacity; 8) proportioning bitumen pump; 9) proportioner.

If the D-150A spreader is not available, the finished mixture used for constructing the upper layer is leveled out by motor graders over the entire width of the coverage section or strip and is compacted by motor rollers. The signs showing that the mixture has been compacted is the absence of tracks when a heavy roller passes and cessation of wave formation ahead of the roll of the roller.

The following set of machines is needed in conjunction with the D-370 mixer:

Dump trucks	as calculated	The D-150B spreader	1
Light motor grader	1	The D-365 roller	1
D-371 or D-415 loader	1	The D-399 roller	2
D-370 mixer	1	D-366 spreader	1

D-164A self-propelled asphalt spreader as calculated

The productivity of this integrated mechanized team is up to 500 meters^{2}shift. The scheme for organizing the flow of work is given in Fig. 76.

The technological process for constructing soil-macadam, soil-gravel, sand-gravel and slag pavements and foundations by mixing at the site in a portable installation such as the D-370 is very close to the process of constructing soil pavements and is not considered separately for this reason. These pavements have a rough, uneven surface for which

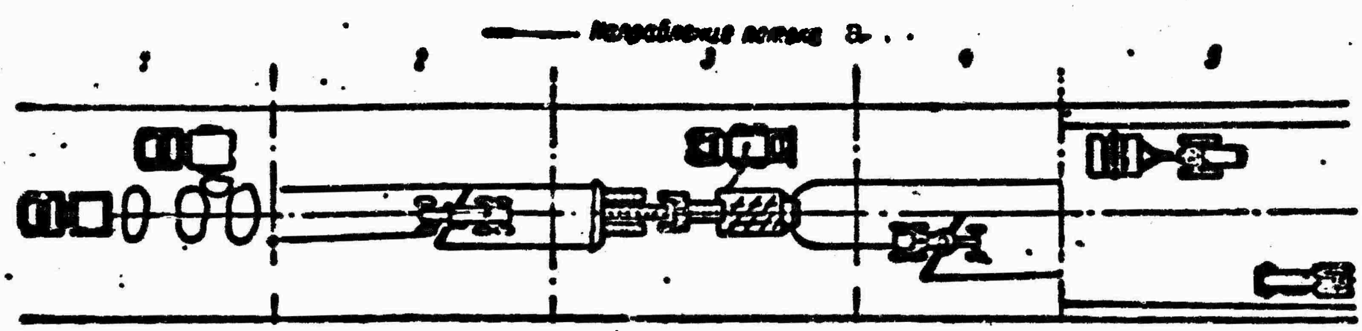


Fig. 76. Scheme of flow in constructing pavements by the on-the-site mixing method using the D-370 mixer. 1) Supply of mineral material by dump trucks; 2) distribution of additives over the gravel material and constructing a windrow by a motor grader; 3) receiving bitumen by the D-370 mixer and mixing of the mineral material and the bitumen; 4) spreading and grading of the bitumen-mineral mixture by a motor grader; 5) compacting the pavement surface by D-260 and D-219 rollers; a) direction of flow.

reason their construction is finished by single or double surface treatment.

Of special importance is surface treatment of black soil pavements, constructed in regions with a hot and dry summer, when the pavements are heated by the sun during the day and become plastic and unstable.

In single surface treatment, after the surface is cleaned of dust and dirt, hot bitumen in the amount of 1.5-2.25 liters/meter^2 is spread on it by a self-propelled asphalt spreader.

The higher application rate is used when the pavement surface is rough and also in regions with a cold and wet climate. Immediately after the binder application, stone fiens or screenings in the amount of up to 1 meter^3 per 100 meters^2 of pavement are spread by the D-336 spreader. The spread stone material is rolled by motor rollers weighing 5-6 tons by 2-3 passes over the same trace. Rolling is repeated in warm periods for a few days after the pavement was constructed.

Double surface treatment consists of the following operations: clearing the pavement of dust and dirt; first binder application (1.5-2 liters/meter^2); spreading of screenings with 15-5 mm grain size in the amount of 1 meter^3 per 100 meters^2; rolling by light smooth rollers

weighing 5-6 tons (5-7 passes over the same trace); second binder application (1-1.5 liters/meter^2) of the same brand and spreading of stone fines or sand in the amount of 0.5-0.8 meters^3 per 100 meters^2.

Cohesive bitumen and hard crushed stone is used for surface treatment, since it creates a wearing layer which increases the pavement strength.

41. CONSTRUCTING PENETRATION MACADAM PAVEMENTS

The penetration method is used in treating new macadam pavements or for reinforcing old pavements. Depending on the availability of macadam-producing materials and the ultimate use of the pavement, penetration may be normal to a depth of 6-9 cm and light-duty to a depth of 4-5 cm.

The main advantage of pavements produced by the penetration method is their high strength, which is close to the strength of the asphaltic concrete pavement.

The disadvantages of the penetration method consist in the fact that it is labor consuming and that the binder is not uniformly distributed over the treated macadam.

For normal penetration the maximal size of the main crushed stone particles is up to 65-70 mm. The crushed stone should be of uniform strength, clean and dry, which will ensure better penetration of bitumen between the crushed stone fractions and adherance of the binder to its surface.

The crushed stone is supplied to the prepared foundation and is leveled out by the motor grader in a layer which is by 25-30% thicker than the design thickness of the pavement (taking into account the subsequent compaction on rolling). Usually the crushed stone is dumped in strips alone the runways. The width of the strip is taken in accordance to the spreading width of the self-propelled asphalt spreader and, de-

pending on local conditions, comprises 15-21 meters. The spread coarse crushed stones are compacted by motor rollers without sprinkling with water and without filling with chippings, first by light and then by medium rollers. The compaction thus produced is incomplete, and is terminated as soon as the stone particles cease moving, but this ensures penetration of the applied bitumen into the entire treated depth. If sections with dirt filled pores between the stone particles are found after rolling, the crushed stone is removed from these sections and is replaced by clean material.

After compacting, the first main application of binder is performed by an asphalt spreader in the amount of 3-4 liters/meters^2. During the first application special care must be taken to keep the depth of penetration of bitumen into the pavement uniform. If individual sections which are either not impregnated or excessively "fat" are found during the application, the obtained application defects should be covered over by bitumen from a manual asphalt spreader, and the bitumen sticking to the thick spots should be removed by cutting it off with a heated iron shovel.

After the initial application the depth of penetration is checked by test boring the pavement.

Immediately after the first, main application, as long as the binder is at a high temperature, small crushed stone with particle size of 25-35 mm in the amount of 3-4 meters^3 per 100 meters^2 is spread by the D-336 spreader. After spreading, the crushed stone is swept into spaces between the main coarse crushed stone fractions; here the fine broken stone should fill the voids but should not creat a separate surface layer.

After the fine crushed stone has been spread and before the applied binder has cooled, the spread layer is rolled by motor rollers weighing

10-12 tons by 3-4 passes over the same trace. The level of the surface is checked by leveling rods in the compacting process. All defects are eliminated by adding crushed stone and binder.

After rolling and correction of undulations a second application of binder is made by a self-propelled asphalt spreader in the amount of 2.5-3 liters per 1 meter^2. Then chippings with 15-25 mm grain size are spread in the amount of up to 1 meter^3 per 100 meters^2 with compaction by 3-4 passes of heavy rollers.

The third binder application deposits 2-2.5 liters per 1 meter^2 and stone fines with 15-5 mm grain size are spread in the amount of up to 0.9 meters^3 per 100 meters^2. The heavy roller makes 4-5 passes over the same trace.

The fourth, final binder application is performed in order to produce a protective layer by single treatment. 1.5-2 liters of bitumen are spread per 1 meter^2. After the bitumen application, screenings or sand is spread in the amount of up to 0.8 meters^3 per 100 meters^2 and final rolling is performed using heavy rollers making 2-3 passes. The total consumption of crushed stone is pu to 13 meters^3 per 100 meters^2 and the total bitumen consumption is up to 12 liters per 1 meter^2.

Light-duty impregnation to a depth of 4-6 cm is performed only in constructing intra-airport automotive roads.

The sequence of operations in light-duty impregnation is the same as in normal impregnation: the difference consists only in the rate of application of the binder and in the dimensions of stone material used. The total consumption of crushed stone in light-duty impregnation is up to 10 meters^3 per 100 meters^2 and the bitumen consumption is up to 9 liters per 1 meter^2. The maximal grain size of the crushed stone used is 35-40 mm.

Gravel and slag pavements, due to their nonuniform strength and

composition lose their strength (have a poor wedging action) when impregnated. For this reason gravel and slag pavements and foundations are most frequently reinforced by organic binding materials by the on-the-site mixing method in portable or stationary mixing installations.

42. CONTROL OF THE WORK QUALITY AND ITS ACCEPTANCE

Soil cement and black airport pavements are accepted by a commission 15-20 days after their construction has been completed.

The quality of pavements is estimated by visual observation and by checking the density, strength and evenness of the pavement and the conformance of linear dimensions and slopes to design specifications.

A pavement surrendered for use should be dense, should not contain spots with excessive or insufficient binder.

The pavement density is checked by passing over it loaded trucks or by taxing of aircraft with full takeoff weight, for which the pavement has been made. Here the depth of tracks on pavements made by the mixing method should not exceed 2 mm, and on pavements produced by the penetration method no tracks should be observed.

The density of soil cement pavements can be determined by ultrasonic inspection by the speed of propagation of a shock wave or by the irradition method using radioactive isotopes.

In accepting a pavement produced by the mixing method its thickness and the mixture quality (color, mixing uniformity, uniformity, lack or excess of binder, etc.) is checked by making cuts in the pavements each 250 meters in the longitudinal direction and in not less than two points at each cross section. The allowable deviations from the design thickness should not exceed $\pm 10\%$.

The physical and mechanical properties or samples removed from the pavement are checked in the laboratory.

The conformance of the pavement slopes is checked by leveling at

each stake. The allowable deviations from design grades may not exceed ± 0.0025. The pavement surface should not have noticeable depressions (saucers), where water may collect. If necessary, the surface level is checked by a 3 meter leveling rod, the microtopography irregularities here allowed are not more than 5 mm.

The linear dimensions of the pavement are checked by a steel measuring ribbon in the logitudinal direction along the runway, taxiway and apron axes and not less than each 200 meters in the transverse direction. The allowable deviations of linear dimensions from design values should not exceed $\pm 1\%$ in the width and $\pm 0.2\%$ in the length. All defects exposed during accepting should be eliminated.

Chapter 6

CONSTRUCTING ASPHALTIC CONCRETE PAVEMENTS

Asphaltic concrete pavements are regarded as nonrigid, permanent pavements possessing high strenght, long service life, elasticity and watertightness. The main disadvantage of this type of pavements is the necessity of constructing strong foundations, dependence fo the pavement construction on local climatic conditions and low temperature stability.

The asphaltic concretes are subdivided by the grain size of the stone material into coarse grained with maximal grain size up to 35 mm, medium grained with maximum grain size up to 25 mm, fine grained with maximum grain size up to 15 mm and sand with grain sizes up to 5 mm. Cold asphaltic concrete mixtures are predominantly fine grained. Most extensively used for pavement construction are hot coarse grained and medium grained asphaltic concrete mixtures.

?3. CONSTRUCTING ASPHALTIC CONCRETE PAVEMENTS FROM HOT MIXTURES

Construction of asphaltic concrete pavements from hot mixtures consists of the following processes: preparing the foundation; preparing and transporting the asphaltic concrete mix; laying the mix; compacting the deposited asphaltic concrete mix and finishing the surface.

Asphaltic concrete pavements are moderate in thickness (4-10 cm) for which reason they are constructed on strong stone or concrete foundations. Old pavements being repaved can be used as foundations.

The foundation on which the asphaltic concrete mix is placed should be level, properly compacted, cleaned of dust and dirt and dry.

All the foundation undulations are made level before placing of asphaltic concrete and are filled with the same material from which the foundation is constructed.

Simultaneously with correcting the surface, the foundation is cleared of dust and dirt by mechanical brushes or by using a compressed air stream supplied by a compressor.

If the foundation is very dirty, washing machines may be necessary for removing the dirt.

The technological scheme of constructing asphaltic concrete pavements is presented in Table 26.

TABLE 26

№ захваток A	I	II	III	IV	V
№ процессов B	1—2	3—4	5—6	7	8
C Описание процессов	1. Очистка основания от пыли и грязи D 2. Розлив разжиженного битума (подгрунтовка)	3. Укладка нижнего слоя E 4. Уплотнение нижнего слоя	5. Укладка верхнего слоя F 6. Уплотнение верхнего слоя	7. Поверхностная обработка G	8. Уход за покрытием H
I Применяемые машины	1. Механическая щетка Д-154 2. Поливо-моечная машина КПМ-1 3. Компрессор 4. Автогудронатор 5. Сушильная машина J	1. Асфальтоукладчик Д-150Б 2. Электростанция ЖЭС-45 3. Катки моторные Д-83 и Д-178Б K	1. Асфальтоукладчик Д-150Б 2. Катки моторные весом 5 т Д-83А То же и Д-178Б L	1. Автогудронатор Д-251 2. Распределитель Д-336 M	Распределитель Д-336 N

A) Number of coverage sections; B) number of processes; C) process descriptions; D) 1. removing dust and dirt from the foundation; 2. Bitumen cutback application (subbase); E) 3. Laying the lower layer; 4. Compacting the lower layer; F) 5. Laying the upper layer; 6, Compacting the upper layer; G) 7. Surface treatment; H) Curing the pavement; I) machines used; J) 1. D-154 mechanical brush; 2. KPM-1 sprinkling and washing machine; 3. Compressor; 4. Self-propelled asphalt spreader; 5. Drying machine; K) 1. D-150B asphalt spreader; 2. ZhES-45 electric generator unit; 3. D-83 and D-178B motor rollers; L) 1. D-150B asphalt spreader; 2. Motor rollers weighing 5 tons D-83A. The same as above and D-178B; M) 1. D-251 self-propelled asphalt spreader; 2. D-336 spreader; N) D-336 spreader.

Subsequent treatment of the foundation by a binder can be performed only after it has dried or after it has been artificially dried by

drying machines.

To ensure reliable coupling between the asphaltic concrete and the old pavement or foundation, after they are cleaned and dried cutback bitumen or tar in the amount of 1 liter/meter^2 of treated surface is applied. The asphaltic concrete mix is laid on newly constructed foundations treated with organic binders after the surface has been thoroughly cleaned without preliminary treatment by binders.

In all cases single layer asphaltic concrete pavements may not be constructed a stone nad gravel foundations not previously treated by a binder.

Preparing and Transporting the Asphaltic Concrete Mix

The asphaltic concrete mix is prepared at plants (Fig. 77). The production process for preparing mixes at the asphaltic concrete plant depends on the required quality and on the design of the mixer used.

Irrespective of the mixer classification the following processes compose the asphaltic concrete preparing operation: sorting and proportioning of mineral materials into the drying drum, drying and heated of materials, preparing and heating bitumen or tar, batching of components is accordance with the specified composition and intermixing them in the hot state. The composition of asphaltic concrete mixes is established by the construction site laboratory in accordance with engineering rules.

Organization of hauling the asphaltic concrete mix from the mixer to the point of placing should satisfy the following requirements: protecting the mix from loses, protecting it from cooling, separating into layers and contamination; the productivity of the transportation facilities should correspond to the productivity of the mixer and the rate at which the asphaltic concrete is placed in the pavement.

The duration of hauling the mix from the mixer to the point of

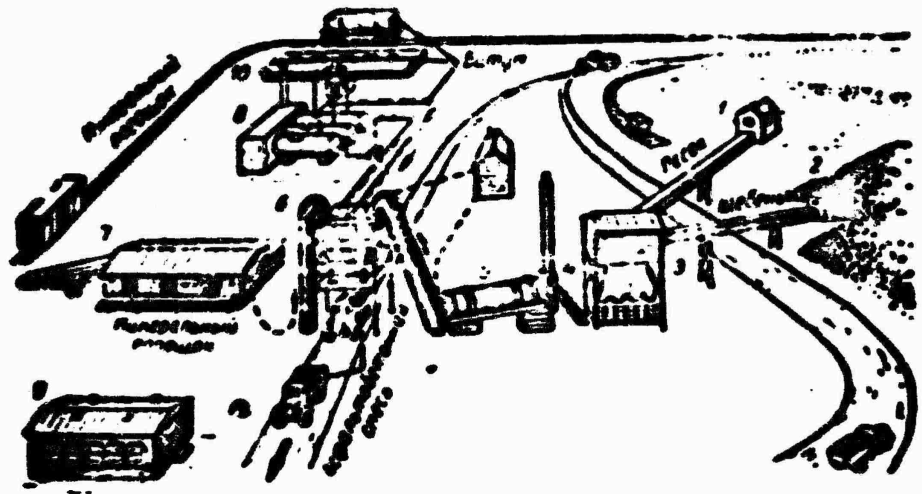


Fig. 77. Asphaltic concrete plant. 1) Sand storage; 2) crushed stone storage; 3) propotioning hopper; 4) stone materials elevator; 5) drying drum of mixer; 6) mixer; 7) mineral powder warehouse; 8) bitumen boilers; 9) laboratory; 10) bitumen storage; a) mineral powder; b) bitumen; c) sand; d) crushed stone; e) asphaltic concrete mix.

placing is established by the construction site laboratory depending on the hauling distance, air temperature and on the time necessary to make the placed mix into a pavement.

Dump trucks are used in airport pavement construction for hauling the asphaltic concrete mix.

The dump trucks used should be clean, in proper operating condition and should have bodies which could be tightly closed.

In order to ensure better sliding down of the mix, the dump truck body should be lightly lubricated at the start of the shift and every 2-3 hours of work by petroleum or spent lubricants.

In order to protect the mix from cooling in prolonged transportation (more than 10 minutes), low temperatures and windy weather, the asphaltic concrete mix should be covered by tarpaulines (Fig. 78) or wooden covers.

Poor state of approach roads results in separating the layers of the asphaltic concrete mix, for which reason they should be maintained in good condition.

The need in transportation facilities for hauling the mix is cal-

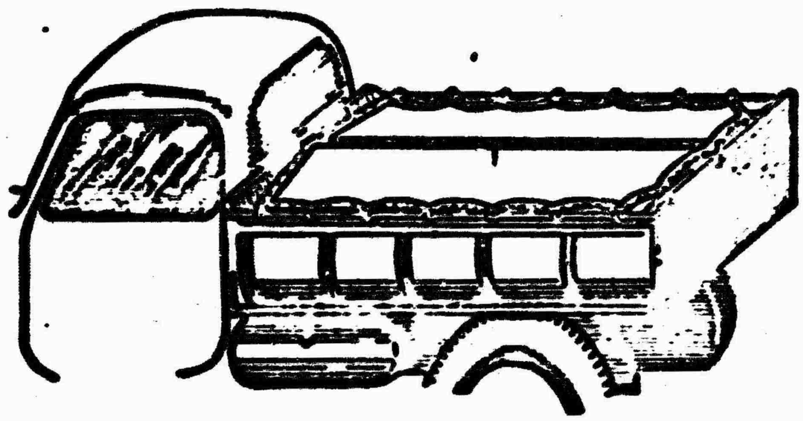


Fig. 78. Tarpauline for the body of the ZIL-585 dump truck in the road position.

culated in the following sequence.

The duration of one trip is calculated:

$$t = t_n + \frac{2 \times 60 l}{v_{sr}} + t_r$$

where t_n is the time for loading the asphaltic concrete mix, minutes; t_r is the unloading time, minutes; l is the hauling distance, minutes; v_{sr} is the average road speed of the truck, kilometers/hour.

The number of trips per shift is determined:

$$n = \frac{60 T K_{vr}}{t},$$

where T is the duration of the shift, hours; K_{vr} is the coefficient of utilization of the dump truck time; t is the trip duration, minutes.

The productivity of the dump truck is calculated:

$$Q = \frac{q}{\gamma} n,$$

where q is the load carrying capacity of the dump truck, tons; γ is the specific weight of the asphaltic concrete mix, tons/meter^3 and n is the number of trips per shift.

The need for dump trucks per shift is determined:

$$N = \frac{Q_{zad}}{Q},$$

where Q_{zad} is the specified rate of placing the asphaltic concrete mix, tons/shift and Q is the productivity of the dump truck, tons/shift.

Placing of the Asphaltic Concrete Mix into a Pavement and Compacting It

Asphaltic concrete pavements from hot mixes are constructed in warm, dry weather at an air temperature of not lower than 10°. The asphaltic concrete mix is placed in one layer 4-5 cm thick or in two layers 7-10 cm thick. The lower limit of pavement thickness is used for medium grain asphaltic concrete, and the upper limit is used for coarse grain material.

Before starting the work and in cold weather the smoothing out plate of the spreader is heated by a nozzle so that the mix does not stick to its surface.

Rolling, vibrating and tamping is used for finish compacting the placed asphaltic concrete mixture after the spreader pass. Rolling by self-powered motor rollers is up to the present time the most widely used compaction method.

The rolling regime approximately requires 5-10 passes of light and 20-25 passes of heavy roller overthe same trace. The total number of passes is 25-30. Rolling is terminated when no traces of rear rolls of heavy rollers are observed. Before the rolling is finished, the pavement surface becomes shiny due squeezed out bitumen.

Self-propelled vibrating rollers have come into use in the last few years for finish compacting of the asphaltic concrete mix. The vibration method increases the degree of compaction and the operational productivity by a factor of 2-3 by decreasing the number of passes, makes possible work at lower temperatures and as a whole decreases the compacting cost by a factor of 2-3.

Vibrating rollers are light weight and lower power consumption in comparison with static action rollers. Stopping the rollers or sharply changing their direction during rolling is not permitted. Compacting should start not later than at a mix temperature not lower than 110-

120° in the case of thick bitumen and 80° for thin bitumen.

When coarse grained asphaltic concrete is used the surface is also subjected to a single treatment.

The asphaltic concreter mix is placed along the runway or taxiway by the D-150B spreader in accordance with the longitudinal or longitudinal-section scheme. After the spread bitumen cutback dries, the lower layer and then the top layer are placed. The time interval between placing of the lower and upper layers should be minimal in order to avoid dirting of the lower layer surface, but placing it may not start before the the lower layer has completely cooled.

Before the spreader starts its work, girders whose height determines the thickness of the layer to be placed, are laid at the edges of the first row. The position of the smoothing plate should be adjusted at the begining of spreading.

The dump truck drives up in reverse until it is tight against the protecting rollers of the spreader and, lifting the body, dumps the mix in the receiving hopper. The spreader pushes the dump truck ahead of itself in the unloading process.

The spreader receives into its hopper upto 7.0 tons of asphaltic concrete mix. Care should be taken in unloading the mix from the dump truck that it slide completely into the spreader hopper. From the receiving hopper the asphaltic concrete mix is, by scraper feed conveyers, fed to two worm conveyers which spread it in a uniform layer over the width of the strip.

The amount of mix supplied to the worm conveyers depends on the pavement thickness and the working speed of the spreader and is controlled by a special hopper baffle. The necessary pavement thickness is obtained by using a regulator.

In spreading the mixture over the foundation by the spreader it is

partially compacted by a tamping beam, and then is leveled out by a smoothing plate.

The most important stage of the technological process in placing of asphaltic concrete is the construction of joints between adjacent strips. Following methods for joining the strips are passible.

Joining each successive strip to the preceding one, which has not as yet cooled, when several spreaders move one after the other at a distance of 5-10 meters. In this case a continuous pavement is obtained without a longitudinal seam. In placing the second strip the spreader is situated so that its smoothing plate is lowered tightly against the edge of the previously placed strip overlapping it by not less than 5 cm, and a space of 3-5 cm is left between the tamping beam and the end of the previously placed strip.

If the succeding strip adjoins the preceding, already cooled strip then in this case the deges of the previously poured strip are chopped off before the spreader pass, and are lubricated by hot bitumen, or the strip's edge is artificially heated up by using a lengthwise pile of hot asphaltic concrete mix. It is best to cut off the edges of the previously laid strip by a disk cutter, mounted on a motor roller.

In all cases an attempt should be made that the adjacent asphaltic concrete strip be joined before the mix cools. In this case the joints are of higher quality. In the summer time using one spreader at an air temperature higher than 20^{o} the length of the spreader pass is taken as 100-150 meters, and in cool weather it is 40-50 meters. When short forced breaks are necessary it is not recommended that the entire mix loaded into the spreaders be used up, but a part of it should remain for maintaining the working temperature. The D-150 spreader is a continuous action machine. Its productivity depends to a large extent on the preparation of the working area and on organizing the mix supply

delivery. Interruption in supply result in downtime of the spreader and in losing a part of the cooled asphaltic concrete.

44. CONSTRUCTING PAVEMENTS FROM COLD ASPHALTIC CONCRETE

Airport pavements are constructed from cold asphaltic concrete by compacting of asphaltic concrete mixes prepared in the hot state.

Asphaltic concrete mixes prepared for laying in the cold state should be capable of being stored for up to one year from the time of preparation and of being compacted on being placed into a pavement at temperatures above 5^{o} under the action of light rollers and truck and aircraft wheel, but should not condense due to their weight (settle in storage). Cold asphaltic concrete mixes are effective when used for repairs. They can also be used for constructing single layer pavements up to 6 cm thick and of a wearing layer up to 2 cm thick.

Cold mixes can be prepared all year round at permanent plants, since they do not lose their initial properties by being kept in storage for a long time. In addition, cold mixes can be transported over great distances by trucks and railroad. Contamination of cold mixes in transit by various impurities (shavings, debris, etc.) is not permitted.

The cold asphaltic concrete mix is placed into a pavement by the same machines used for the hot mix. The main feature is rolling which, after the spreader pass, is performed by light or medium rollers by 3-4 passes over the same trace. Finish compaction of the pavement of wearing layer made from cold asphaltic concrete is achieved by intensive truck or aircraft traffic. 2-3 months are required forming and hardening of the pavement.

45. ACCEPTING THE WORK, CONTROLLING ITS PERFORMANCE AND SAFETY MEASURES IN CONSTRUCTING PAVEMENTS AND FOUNDATIONS

Receiving the Work and Controlling its Quality

The quality of asphaltic concrete operations can be checked vis-

ually, by instruments an . in the laboratory.

In accepting the mix at the sit of placing its temperature, homogeneity and size should be checked. The placing temperature of the mixture is determined by the field laboratory depending on the bitumen properties and the weather condition in the placing period.

The homogeneity of the mix is checked visually. It should not contain concentrations of uniformly sized material, dense bitumen spots, or individual grains which are not covered by bitumen. The greatest grain size of stones in the mix for the lower layer of twin-layer pavements and for single layer pavements should not exceed 0.7 of the theikness, and for the upper layer it should not be greater than 25 mm.

The foundation thickness should conform to that specified by the paln, should be clean without dents and defects. The elevations and grodes of the surface should conform to design specifiactions. After the asphaltic concrete has been placed, the pavement surface should not contain blow holes, saucers and cracks. The pavement should not have discontinuities and cracks at joints of individual strips. The elevations of the pavement surface may deviate from design specifications by not more than 5 mm. The thickness of the pavement layer is checked by test cuts (not less than one from an area of 2500-3000 meters^2). Deviations on the lower side may not excedd 10% of the pavement thickness. The level of the pavement surface is checked by a 3 meter leveling rod. The gap should not exceed 5 mm.

The degree of compaction is checked by laboratory methods by cutting samples from the pavement.

Traffic over the pavement starts after rolling when the mix cools.

Safety Measures in Constructing Pavements and Foundations

Organic binders. Danger to the health of workers working with organic binding materials consists in the fact that these materials are

used in the hot state, their vapors are difficult to remove when splashed on the skin and continuous effects result in chronic skin deseases. The following requirements must be satisfied when working with organic binding materials.

Loading and feeding them into boilers for steaming should be performed only at night or during cool hours of the day.

All workers working with tar, bitumen and coal pitch should be provided with canvas clothing, gloves and goggles.

Tar and pitch should not be allowed to touch the skin.

Not more than 3/4 capacity of the boiler should be filled with bitumen for heating. The boiler should have a cover and reliable fence.

Bitumen melting boilers should be provided with fire extinguishers, shovels and sand boxes.

Binder which has ignited in the boiler should not be extinguished with water; the flames can be beaten down with sand or by placing the cover on the boiler.

The entire technical personnel and workers servicing the boilers should be trained in safe methods of working with binders and should work strictly according to instructions.

The self-powered asphalt spreader nozzles should be shut off during spreading of the binder.

Mineral binders. The following requirements muct be satisfied when working with mineral binders (cement and lime).

Closed cement and lime warehouses should be ventilated.

All hole type lime storage places should be fenced in or covered.

Worm conveyers, elevators and cement lifting equipment should be covered by hermetic covers.

Workers charged with unloading and packing of cement should be provided with respirators and goggles.

Chapter 7

CONSTRUCTING CONCRETE AND REINFORCED CONCRETE PAVEMENTS

46. GENERAL CHARACTERIZATION AND COMPOSITION OF OPERATIONS

Concrete and reinforced concrete monolithic pavements are the basic types of permanent pavements at modern permanent airports. The high strength, long service life, low surface wear and the feasibility of utilization of integrated mechanization has made then in the last few years into the most extensively constructed pavements in comparison with those made from other materials.

Concrete pavements are constructed in either one or two layers on artificial foundations. Twin layer pavements are designed in order to use in the lower layer local less strong stone materials (gravel, stone limestone, etc.). The thickness of the lower layer is taken as approximately 2/3 of the total thickness of the twin-layer pavement, while the thickness of the upper layer should not be less than 8 cm. Twin-layer pavements are constructed either as monolithic or with a separating elastic strip between the layers. In the latter case the seams of the upper layer are displaced with respect to the seams of the lower layer by half the size of a plate, which produces reinforcement of edge and corner sections of the upper layer plates.

Pavement plates are usually rectangular in shape with dimensions in the plan without reinforcements from 3.5 × 3.5 to 3.5 × 5.0 meters, if 7 × 7 meter and larger reinforcement mesh is available. The plates are sparated by expansion and compression seams.

In order to reinforce edges and corners of plates and in order to provide for joint work under load, adjacent plates are interconnected by dowels or metal pins. Through vertical seams are used in pavements constructed on rigid foundations and in reinforced concrete pavements on having soil.

Reinforced concrete pavements are constructed for heavy aircraft loads, under unfavorable soil and hydrologic conditions of the construction region, at points where the pavement interests with communication and utility network, at points at which taxiways join runways and aprons and at terminal site ramps.

In reinforced nonstressed pavements the reinforcements can be placed over the entire plate area, along its perimeter or at transverse seams.

If the operations cover a sufficient area, then concrete and reinforced concrete nonstressed pavements are constructed by the mechanized high-speed flow method. The flow consists of the following operations: final grading and rolling of the bed bottom; constructing the foundation; placing and removal of side forms; placing and fastening of metal dowels and other elements of butt joints; manufacture, transportation and placing of reinforcements (if this is provided for by the design); preparing and transporting the concrete mix; placing the concrete mix; cutting and pouring of seams; concrete curing.

The enumerated operations are performed by an integrated group of concrete placing machines.

Concrete placing machines with the D-181V modernized concrete spreader were up to the recent pass most commonly used in airport construction. A set of these machines consists of the D-247 side form placer, the D-181V concrete mix spreader with side loading, the D-182V finishing machine and the D-195V joint sawing unit.

Starting with 1958, serial production of these machines has been discontinued, but they are still used by airport construciton organizations and conform to the requirements of airport concrete pavements construction. At the present time the airport construction organizations are receiving a new set of concrete placing machines with the D-375 spreader, which have an increased productivity and are capable of compacting rigid concrete mixes.

Placing of concrete by using limited mechanization facilities in the construction of pavements is limited only to sections where the efficiency of using a set of concrete placing machines is low or their use is entirely unfeasible (joints between runways and taxiways, of taxiways with individual sitting points, hangar-site areas, small terminal ramps, etc.).

47. CONSTRUCTING THE SUBPAVEMENT BED

The flow of earth moving operations at the pavement construction sections is terminated by rough grading and rolling of the subpavement trench bottom. Finish grading and rolling of the trench is performed in accordance with leveling elevations immediately before constructing the foundation, at rates equal to the sections of concrete placing operations (leaving of finish graded trenches not filled with a layer of foundation material for longer than a day is not recommended), which makes it possible to protect the trench from damage due to precipitation, the sun's rays, traffic of transportation facilities and trampling by people in rough weather.

Basic grading of the trench bottom is performed, in accordance with leveling elevations, by a motor grader with simutaneous compacting by rollers of various weight. In order to ensure high surface quality in hot and dry weather, it is recommended that the trench bottom be graded and rolled in the first half of the day with preliminary

sprinkling of the surface to be graded in the evening of the preceding day. In this case the surface, after grading and rolling, will be level with a hard monolithic crust.

All local sags of the trench exposed by the rolling are corrected by filling of the same soil from which the trench is constructed; here the reason for the sagging should be discovered and elimінted. If the sagging is a result of low soil quality, then it should be replaced by stable soil. Overmoist soil should be dried or replaced by optimally moist soil before grading.

After the basic grading and rolling is done, sample grading is performed at points where adjacent lateral and longitudinal grades are joined, at the location of the open ground gutter of the trench; edges are finished off and other irregularities are corrected.

Unstable trench soil is improved by various additives (sand, gravel, curshed stone, cement, organic binders), which is done before final grading of the trench and is not included in the concrete placing flow.

The level of the trench bottom surface is checked by a 3 meter leveling rod. Allowable irregularities are within the limits of 3 cm and must be provided with water runoff. Transportation facilities and construction machines and workers in rough weather may not move over the finished trench.

Finish grading and rolling is performed by a team consisting of 9-10 workers. The theoretical productivity of this team is up to 1250 meters^2/shift. This team is a part of the integrated foundation laying brigade.

Great reserves for increasing the productivity and improving the quality of grading operations are opened up by using automatic controls for motor graders. Tests of an automatic system on the D-426 motor gra-

der have demonstrated the feasibility of using automatic control of the working elements of the motor grader in performing finish grading and finishing the trench bottom surface.

The use of this control system ensures the necessary finishing quality in 1-2 passes at increased speeds (up to 5-6 kilometers/hour).

A great influence on the work of the automatic controls is exerted by the state of the ground surface before the work starts, and also by the soil density and its uniformity over the width of the coverage section. Presence of tracks, furrows and other surface irregularities higher than 20-25 cm makes the use of automatic controls ineffective.

48. CONSTRUCTING FOUNDATIONS

Foundations are the carrying part of the pavement, whose strength and stability determines to a considerable extent the service life of concrete or reinforced concrete pavements. Sand, sand and gravel mixtures, crushed stone, slag, binder treated soil, sand-concrete, lean-mix concret, and also simple and improved pavements, upon rebuilding, are used as foundation for concrete and reinforced concrete pavements. The design and type of foundation for each individual case is determined by design.

Sand foundations are up to the present time the most extensively used for concrete and reinforced concrete pavements. They are economical, simple to construct and do not require scarse brought-in material. Sand foundations are produced from sand satisfying requirements given in Table 27. Before the work of constructing the sand foundation starts all work pertaining to the construction of drainage installations and finishing the trench bottom within the limits of the coverage sections should be completely finished.

Construction of sand foundations is broken up into two stages. The first stage is performed before the placing of paving forms or molds,

TABLE 27

Песок 1	Задерживается на ситах с отверстиями (% по весу) 2					Содержание пылеватых частиц (мельче 0,05 мм), % по весу 3	
	2 мм 4	1 мм 4	0,5 мм 4	0,25 мм 4	0,15 мм 4	для зоны умеренного увлажнения	для зоны избыточного увлажнения
Крупный 7	До 35	>50	—	>90	—	7	6
Средний 9	До 25	—	>50	>75	90	5	4
Мелкий 10	До 10	—	—	>50	90	4	3
Очень мелкий 11	— 8	—	—	>60	90	4	3

1) Sand; 2) is retained in sieves with holes (% by weight); 3) dust particles (finer than 0.05 mm) content, % by weight; 4) mm; 5) for moderate precipitation region; 6) for excessive precipitation region; 7) coarse; 8) up to; 9) medium; 10) fine; 11) extra fine.

and the second stage is performed afther placing of paving forms. The composition of the first stage operations for constructing of sand foundations includes: pegging out the foundation; hauling in and filling of sand into the trench; leveling out the sand; by layer compaction of the sand with attendant sprinkling.

Depending on the assumed scheme of pouring the pavement, the sand foundation is constructed in individual strips or over the entire width of the trench. Before the sand is trucked in the trench should be checked and accepted and the strip should be stacked out by placing pegs every 20 meters on both sides when pouring nonadjacent strips, and from on side when pouring adjacent strips, using a theodolite. The height of the pegs is established, by a leveling instrument, at the design height of the fouudation, taking into account the sand compaction coefficient which is taken as 1.1-1.15. Between control pegs placed by a leveling instrument, intermediate pegs are placed by ranging rods every 5 meters in order to ensure uniform spreading of the sand.

After staking out the foundation material is trucked into the trench by dump trucks or by large capacity trailers. Truck traffic over the surface of the prepared trench is allowed only in the cases

when the trucks do not leave tracks and in constructing foundations for nonadjacent rows. In all cases, if possible the sand is brought in over previously poured concrete pavement after the concrete has acquired the design strength.

Portable wooden floorings are placed at the point at which trucks drive on or off the concrete pavement.

The sand brought in is distributed uniformly and leveled out over the length and width of the strip being filled by a bulldozer or motor grader in a manner which will not damage the surface of the soil trench (Fig. 79). Leveling is performed in sections not less than 400-500 m long.

Best compaction of sand is achieved when its moisture content is close to optimal (approximately 10-12%). For this purpose the sand is sprinkled with water before being compacted in dry weather.

Compaction is first performed by the bulldozer crawlers and then by rollers, whose weight is gradually increased. In the first stage of sand foundation construction extreme care should be taken to produce the proper thickness, without allowing depressions or elevations, which can cause a great amount of additional work. In the second stage of foundation construction the team charged with constructing the sand foundation should be provided with self-propelled rollers on pneumatic tires, by vibrating rollers, smooth self-proprlled rollers, bulldozer, motor grader, surface vibrator, sprinkling machine and dump trucks whose number is calculated on the basis of the hauling distance.

The theoretical productivity of such a team is up to 1250 meters^2 per shift for a foundation thickness up to 30 cm.

The sequence for constructing crushed stone, slag and soil foundations treated by binding materials was considered in Chapters 4 and 5, and that for constructing foundations from sand concrete and lean-mix

concrete is the same as for concrete pavements. Sand concrete is prepared at a concrete plant, its brand is not lower than 75 and it is made from coarse grain sand and cement. The consumption of cement whose brand is not lower than 300 is up to 250 kg/cm^2.

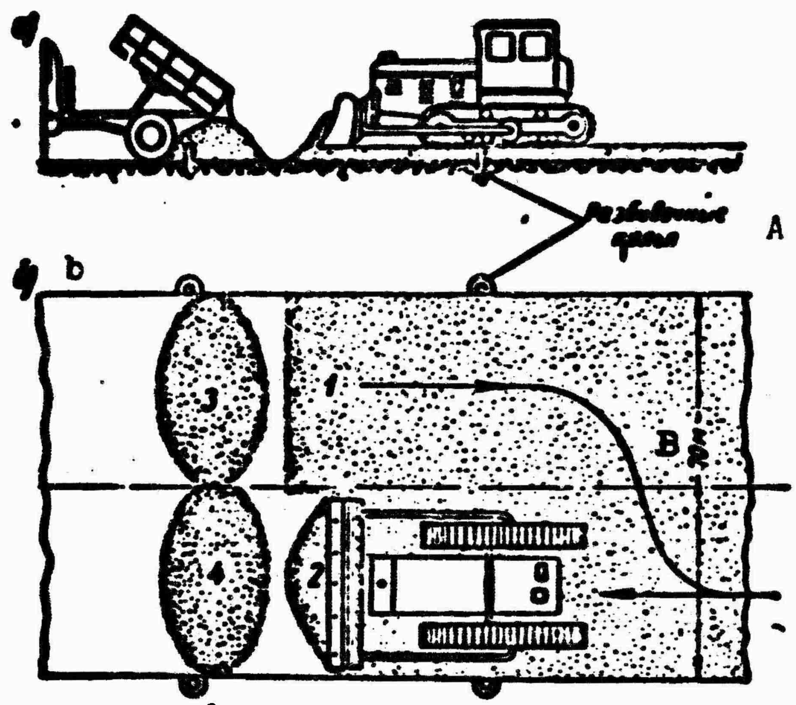


Fig. 79. Sequence of unloading sand in the trench by dump trucks and leveling it out by a bulldozer. a) Scheme of unloading a dump truck and leveling out of sand in the trench by a billdozer; b) scheme for unloading sand piles in the trench and the sequence in which they are leveled out by the bulldozer; 1-4 is the sequence for unloading a dump truck with sand at the coverage section strip; A) grade stakes.

Sand concrete is placed directly in the soil trench or on a sand-bitumen blanket by a set of concrete placing machines. No joints are constructed in sand concrete foundations.

Before placing the paving forms, if the foundations are constructed of crushed stone, gravel of soil treated by binding materials, a leveling sand layer 3-5 cm thick from screened sand is additionally placed on the top of the foundation.

49. PLACING OF PAVING FORMS AND MOLDS

In the process of laying the concrete mix, the concrete placing machines move over paving forms which at the same time serve as molds for forming the side faces of the pavement slabs. Incorrect placememt

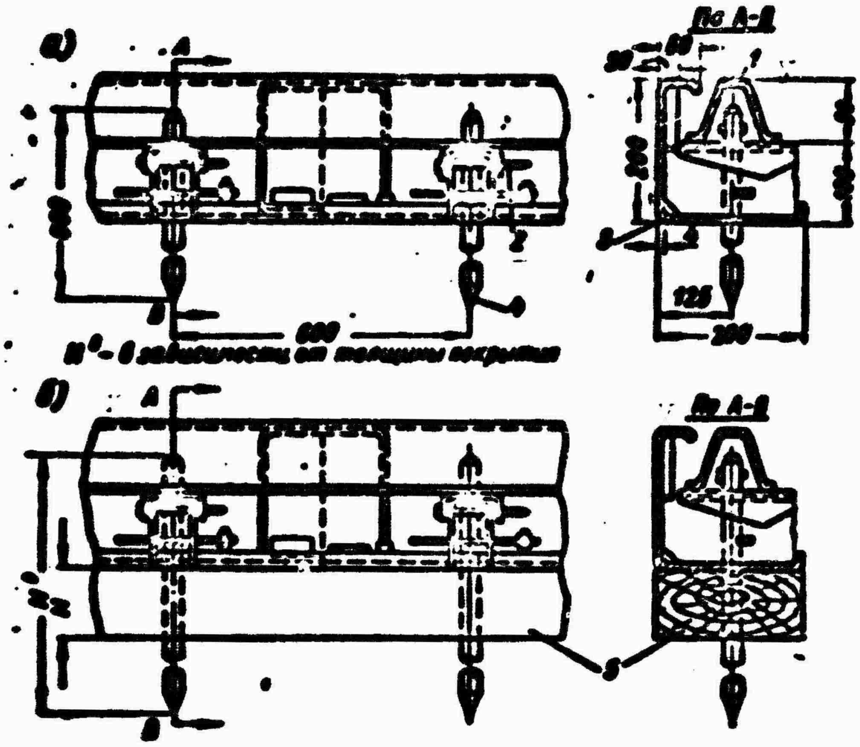


Fig. 80. Design of a side form. a) For pavement thickness yp to 20 cm; b) for pavement thickness over 20 cm; 1) rail; 2) dey; 3) form; 4) pin; 5) wooden girder; x) depending on the pavement thickness; y) section A-B.

of paving forms has a negative effect on the evennes of the pavement, and may also cause the concrete placer do be derailed.

Standard side forms are produced 20 cm high, 4 meters long and weighing up to 180 kg. When pouring thicker pavements the height of the side forms can be increased by wooden girders (Fig. 80).

The placing of paving forms begins with setting out operations. Before laying out, a theodolite is used to determine the paving form's direction and an elevation peg giving the position of the paving form top at the level of the pavement surface is driven in against each joint.

Before placing, the paving forms should be inspected, cleaned and repaired. The straightness and verticality of the walls is checked as well as the proper operation of joint connections and correspondence of dimensions.

The paving forms are brought in by trucks or tractor trailers. The

pavement forms are loaded, unloaded, placed and removed by truck cranes or by the D-247 placer.

In placing of paving forms care should be taken that they be vertical; that the design width of the strip subject to pouring be conformed to; it is also necessary to ensure uniformity of compacting the paving form foundations by special mechanization facilities (area vibrators; electric crosstie swaggers, tamping machines, etc.).

The paving forms are put in the design position by a crane using special holding devices and in accordance to a string stretched between pegs. Each successive section is butt joined to the preceding one; then the free end of the rail sticking out from the form should be placed in a direction opposite to that of laying the paving form.

The conformance of the paving form placement to the design elevations is checked by a level placed on the top of the rail and on the top of the elevation peg which was driven in opposite the joint. The position of the paving forms in the plan is checked by a theodolite or template.

After each successive paving form is placed, their ends are fastened by sliding steel slide-locks and the ends of the rails are fastened by wedges. The paving forms are fastened to the ground by small metal piles (pins up to 900 mm long). The pins are driven in through holes in the lower flange of the form as far as they will go so that they do not interfere with the movement of the concrete placing machines.

The reliability and correctness of paving form placement are checked by two passes of the D-345 subgrader or of the D-181V bin distributor. The subgrader is passed through with the vibrators on and the last pass of the bin distributor is performed with its bucket loaded with sand.

After the control passes of the D-345 or D-181V machines the check of the elevations of each joint between the paving form sections is performed by leveling. Deviations of the paving form elevations from those specified by the design should not exceed ±3 mm. Inaccuracies in placing the paving forms with respect to height are corrected by forcing the necessary amount of sand under them or by removal of excessive sand, The paving form "threads" are rectified in the plan by moving them.

The production of a machine for integrated mechanization of paving form placement (Fig. 81) is being now assimilated. The working equipment of this machine finish grades to the design elevations and compacts the sand base course for the paving forms 0.6 meters wide, places the paving form section, joining then "in the thread" and fastening the placed sections by metal pins.

To the side of the tractor is situated beam 4 with optical tube 7. The placing beam is supported by its rear end on the paving form through the rolling support 8, and by forward end it is suspended from vertical displacement mechanism 1 and horizontal displacement mechanism 9, which are also the mechanisms for aligning the optical tube. The vibrating compacting and grading unit 2 and electric hammer 6 moving along a carriage over the beam are mounted on the placing beam. The paving form sections are placed by crane 9.

The paving form sections thus placed are fastened by metal pins driven in by the electric hammer. The productivity of this machine is up 500 linear meters of paving forms per shift (in a single line). In all cases the paving forms should be placed only in the daytime. For this reason the rate at which they are placed should be such as to ensure not less than two shifts of work for concrete placing machines.

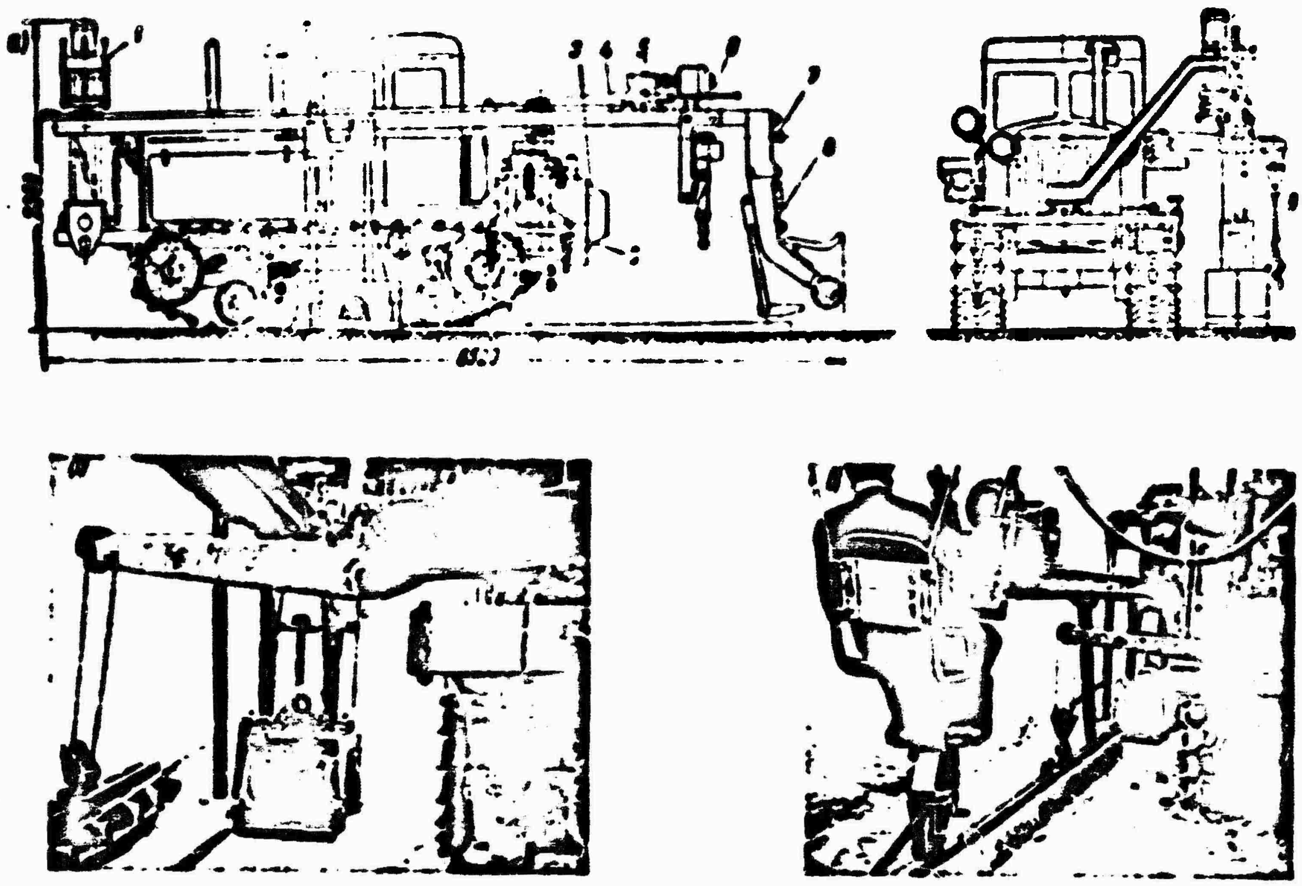


Fig. 81. Mounted equipment for the DT-54 tractor for placing of paving forms. a) General view; b) preparing of foundation by the compacting and grading machine; c) placing a paving form section on the prepared foundation; 1) mechanism for lining up the placing beam with the ranging rod; 2) vibration compacting and grading machine; 3) generator; 4) placing beam; 5) winch for moving the compacting and grading machine along the beam; 6) electrical hammer for driving of pins; 7) optical tube for aligning the beam; 8) rear rolling beam support; 9) crane for placing of paving form sections.

50. FINISH GRADING AND COMPACTING OF THE SAND BASE COURSE BY THE D-345 SUBGRADER

A grading blade and compacting vibrating beam are the working elements of the D-345 subgrader (Figl 82).

The grading blade is placed in front and consists of a welded beam to which replacable grading knives have been fastened. The length of the blade can be changed depending on the width of the pavement being constructed (for pavement width of 3.5 meters the blade length is 3.46 meters, for 5 meters it is 4.96 meters and for 7 meters it is 6.96 meters). The blade height is 50 cm. If it is reauired to change a plane 7 meter singly inclined profile to a crown shaped section is is suffi-

cient to replace the grading knife with out changing the blade proper. The compacting vibrating beam is placed behind the grading blade and consists of a riveted beam with mechanical vibrators mounted on it.

The special raising mechanism on the subgrader makes it possible to lower the blade and the vibrating beam by 52 cm lower than the rail tops and to raise it by 10 cm above them. Before the subgrader starts operating its working elements are adjusted if this is necessary.

The cutting edge of the grading blade and the lower plane of the vibrating beam should be placed in a strictly parallel position: first by wheels they are placed on the level of the rail tops; here 0 should show on the scales of height gages for the vibrating beam and the grading blade; then the beam is lowered to a height corresponding to the thickness of the concrete pavement being constructed.

The working elements of the machine should be situated symmetrical with respect to the axis of the pavement subjected to pouring. The adjustment is made by changing the number of washers under the hubs of the track wheels in such a manner that the gap between the ends of the working elements (blade and vibrating beam) and the molding part of the paving form be the same (about 20 mm).

The relative position of the working elements with respect to height is determined experimentally depending on local conditions (the composition of the sand material, the degree of its precompaction, surface regularity and other factors). The blade should be raised by the amount by which the sand layer settles on compacting.

The blade is adjusted with respect to the vibrating beam by special screws and at different angles with the horizontal in the following sequence. The vibrating beam is positioned at eht elevation of the pavement surface; as the machine works, the blade is gradually raised. Simultaneously with raising the blade the forward edge of the vibrat-

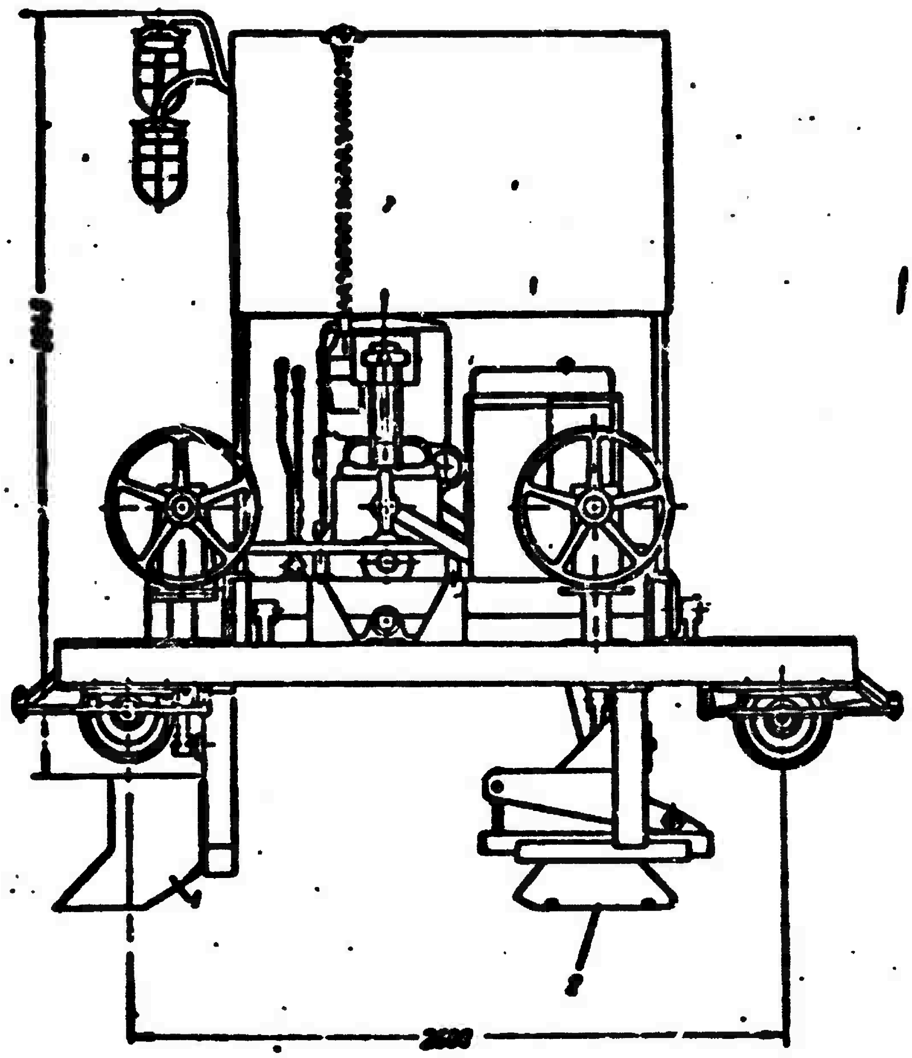


Fig. 82. Diagram of the D-345 subgrader. 1) Blade with grading knife; 2) compacting beam.

ing beam is raised in order to create drive-on angle until the sand layer finally settles.

The sign showing that the drive-on angle has been properly choosen is the fact that a uniform longitudinal sand pile up to 10 cm high is formed during the work of the vibrating beam at its forward pa ..

Finish compaction and grading of the xubgrade starts with determining the sand moisture content. If necessary, it is brought to optimal by using sprinkling machines or by drying. The D-345 subgrader grades and compacts a sand layer of up to 30 cm with a compaction coefficient not lower than 0.98 in 2-3 passes. The density of the compacted base course is checked by Kovalev's instrument by the standard compacting method.

In operating the subgrader extreme care must be taken that a small sand windrow, uniform over the entire length of the blade be always present ahead of the blade. In the opposite case the density of the sand layer along the width obtained by the vibrating beam operation may be found to be nonuniform. The excessive sand cut off by the blade is removed with shovels outside the limits of the section to be poured or is redistributed to lower lying places, where its amount is insufficient. For this reason, in addition to the operator, the subgrader is serviced by 1-3 helpers (the number of helpers is determined on the basis of the precision with which the sand foundation is constructed at the first state, i.e., before the placing of the paving forms).

The average productivity of the D-345 subgrader for a sand foundation thickness of up to 30 cm reaches 40 linear meters/hour.

The previously produced set of concrete placing machines did not contain a special subgrader. For this reason, in those places where concrete pavements are constructed by this set, the sand foundation is leveled out and compacted by low level mechanization facilities.

In this case work also starts after placing the paving forms sprinkling (drying) and compacting of the sand layer, and finish leveling of the foundation is performed by a template made from boards.

The template, placed on dege, resting by constructed projections (or wheels) on the upper faces of the paving forms, should by its lower part touch the surface of the sand foundation at the required height. In this case the foundation is graded by pulling the template by a tractor (the template as if performs the functions of the subgrader blade).

The practice of construction organizations knows about successful solutions for using machines of the older set for leveling and finish grading of the sand foundation. For this purpose a blade is installed

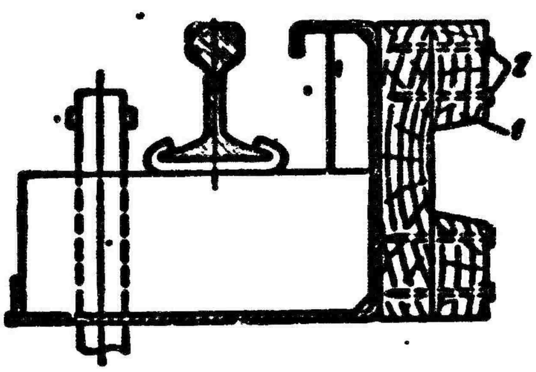


Fig. 83. A molding form placed to the side of paving forms for forming longitudinal joints with the groove. 1) boards; 2) nails.

on the frame of the D-247 self-propelled paving form placing machines, taking previously into consideration the pavement thickness.

As the crane moves forward such a blade levels out the foundation exactly in accordance with the elevation. The graded foundation in this case is finish compacted by S-414 surface vibrators. The position of the blade is adjusted by all kinds of devices. In addition to the operator, the crane is also serviced by two helpers, which perform the same work as with D-345 subgrader.

As was previously noted, the paving forms perform the functions of molds. In constructing of pavements (runways, taxiways and strip aprons) this is correct in the full sense of the work only when producing their edges, when the longitudinal edges of the slabs are formed by the vertical web of the paving form. In pouring inside rows of pavements, for ensuring joint work of slab rows, a tongue and groove joint is usually constructed in the longitudinal seams using a wooden side mold (Fig. 83). The side mold is placed after the paving forms are assembled and the foundation is finish compacted. The mold sections are fastened from the bottom (pressed against the smooth web of the paving forms) by wooden pegs, and form the top they are fastened to the paving forms by metal clamps or braces which are welded to them. The clamps or braces are removed when finishing the slab surfaces.

The height of the added molds should conform exactly to the thickness of the pavement being constructed. The mold edges should be rectilinear and the surface facing the concrete should be smooth and clean and before pouring it should be lubricated by a clay or lime solution.

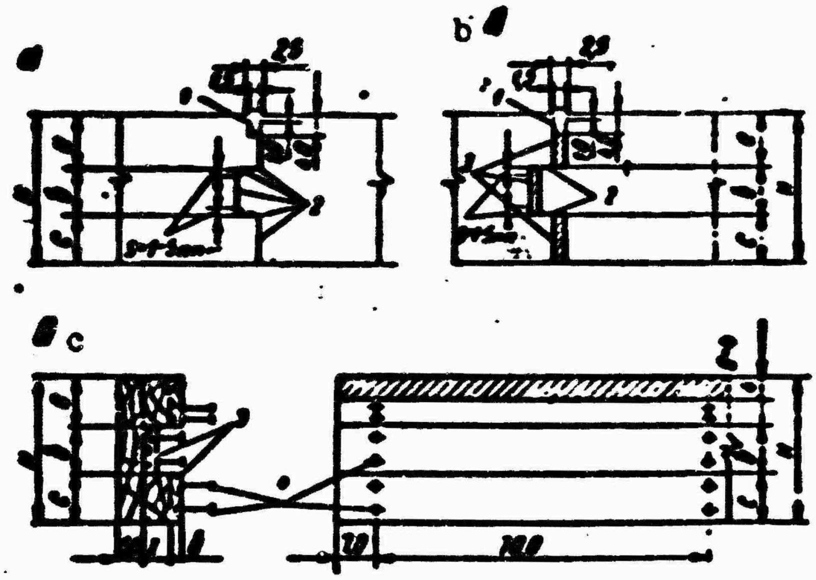


Fig. 84. Schemes of tongue and groove joints between slabs. a) Compression joint; b) expansion joint; c) mold for a tongue and groove joint. a) bitumen mastic; 2) bitumen application δ = 1-1.5 mm); 3) wooden spacers δ = 15 mm); 4) nails.

In logitudinal expansion joints wooden spacers 15 mm thick are fastened to the vertical cases of the added molds. The upper spacer is lower than the pavement surface by 4-5 cm (Fig. 84).

The setting out pegs are removed when the additional molds are placed. It is recommended that the spaces between the molds and the rail be filled with soil or sand, in order to prevent the concrete mix from falling into them on pouring.

After the concrete strength reaches a values of not less than 30 kg/cm^2 the paving forms and the molds are removed. The recommended time for keeping the concrete in the molds can be determined from the graph giben in Fig 85. But if the timber molds were used, the paving forms can be removed earlier. In warm summer weather the paving forms can be removed after 8 hours after finishing the concrete surface, while the timber molds can be removed after 20-25 hours. The timber molds make it possible to considerably increase the turn-over of the paving forms.

The paving forms and timber molds are removed in an order opposite to that of their placing. First a special crowbar is used for remov-

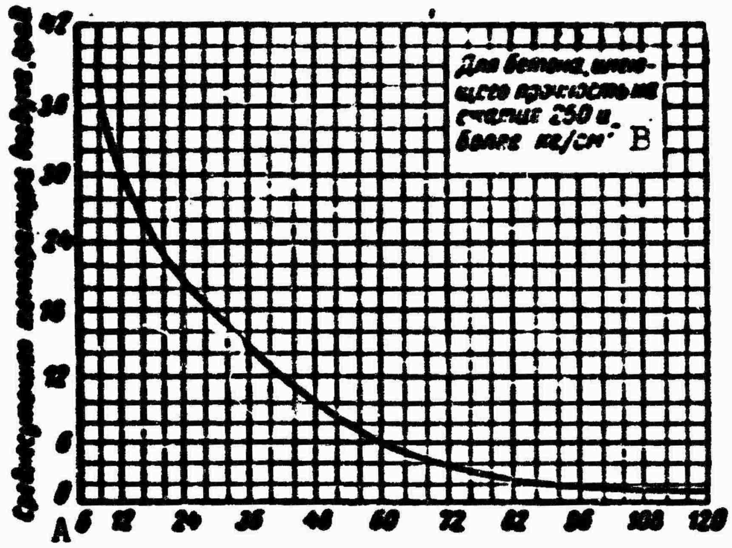


Fig. 85. Graph showing the dependence of the time concrete is kept in the timber molds on the average daily air temperature. A) Average daily air temperature, degrees; B) for concrete with a compression strength of 250 and more kg/cm².

ing the pins, which are cleaned of aoil and concrete and placed on the pavement in crates, and the paving forms are uncoupled.

As the paving forms are removed they are loaded by a crane and transported to the following placing point, or are moved to the new placing point in case of adjacent row pouring. Thus, the paving forms are dismantled section by section in succession, strating with the begining of the concrete pouring section. The timber molds are separated from the pavement, starting from one end, using a special hook and crowbar. Removing the timber molds by driving wedges between the concrete and the molds or by hitting with the crowbar is forbidden. In order to facilitate the removal of the timber molds and to protect the slab faces from damage use is made of a wooden shoe, made in the shape of the side face of the slabs with a tongue (Fig. 86).

After the timber molds are removed the naked vertical walls of the concrete pavement are covered by moist sand or treated by film forming materials.

Before placing the concrete mix, if this is provided for by the design, a protective bitumen blanket is constructed or water-resistant

paper is spread over the sand course, in order to prevent the concrete slabs from freezing to the foundation in the winter time, and also to protect the lower concrete layer from thinning out due to intensive absorption by the sand of the cement grout during pouring of the pavement. The paper is spread with overlapping of rows by at least 10 cm.

The following set of machines is used for placing and removing the paving forms, finish grading and compacting of the sand foundation:

The K-32 truck crane or D-247 paving form placing machine	2
The PM-8 sprinkling machine	1
The ZhES-50 portable electric station	1
The D-345 subgrader	1
A tractor with trailers for transporting the paving forms	1

The productivity of a brigade equipped with these machines is 40 linear meters/hour. The minumum amount of paving forms should comprise 600-800 meters in two lines per each set of concrete placing machines.

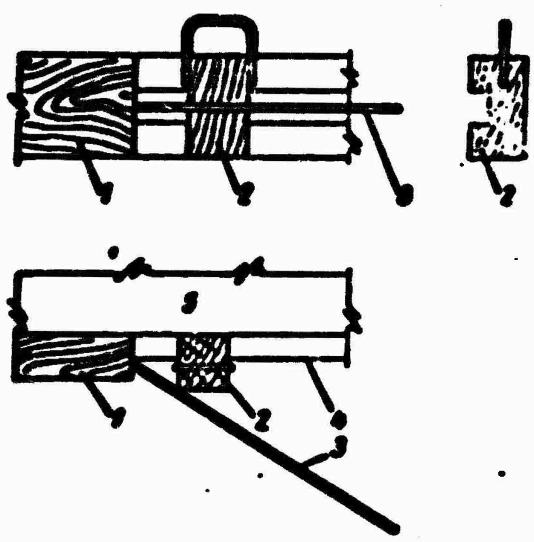


Fig. 86. Removing the timber molds by a special shoe and crowbar. 1) Timber molds; 2) special shoe; 3) crowbar; 4) tongue of the tongue and groove shape; 5) concrete pavement.

51. FABRICATION, TRANSPORTING AND PLACING OF REINFORCING CAGES

Reinforced concrete monolithic airport pavements are reinforced by reinforcing meshes or cages from smooth or hot rolled steel of periodic profile.

The upper and lower working reinforcements of the cage consist of welded mesh interconnected by vertical rods of the installation reinforcements (Fig. 87). The amount of reinforcements in a slab is determined by the plan and varies from 13 to 28 kg/meter^2. Sometimes structural reinforcement is performed of edge sections and slabs at through joints (Fig. 88) and also in the form of reinforcing cages with

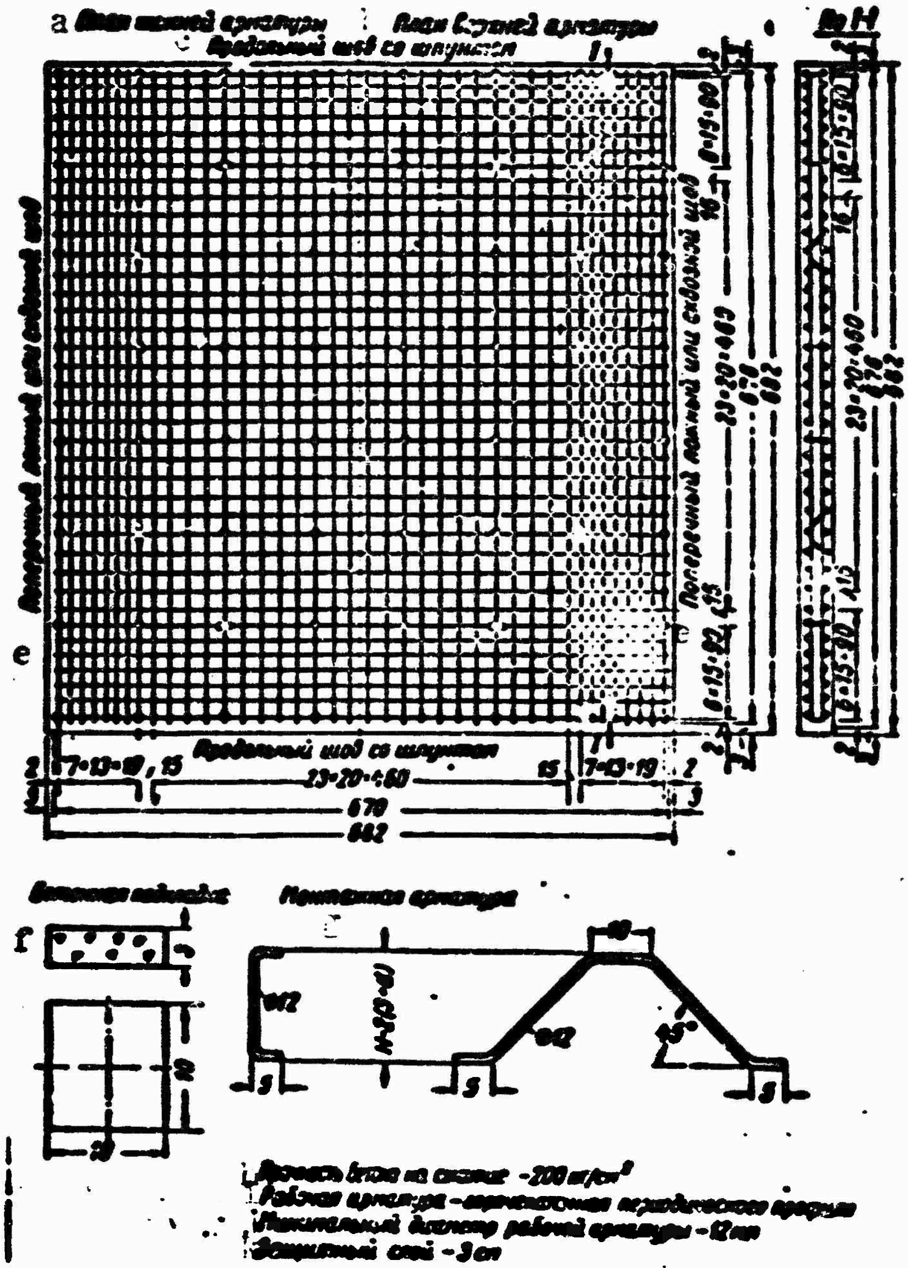


Fig. 87. Scheme of continuous reinforcement of reinforced concrete slabs (7 x 7 meters). a) Plan of bottom reinforcements; b) plan of top reinforcement; c) longitudinal tongue and groove joint; d) section I-I; e) transverse dummy or throught seam; f) concrete spacer; g) installation fastening accessories; h) compression strength of concrete is 200 kg/cm^2; i) working reinforcements are hot rolled with periodic profile; j) minimal diameter of the working reinforcements is 12 mm; k) protective layer - 3 cm.

wire diameter of 12-14 mm with from 6 to 8.5 kg/meter^2 of plate used. The fabrication of cages requires a large expenditure of the labor force. It also requires high quality work.

The reinforcements placing operations include preparing the rods, welding of meshes and cages, transportation and placing of finished cages at the pouring location.

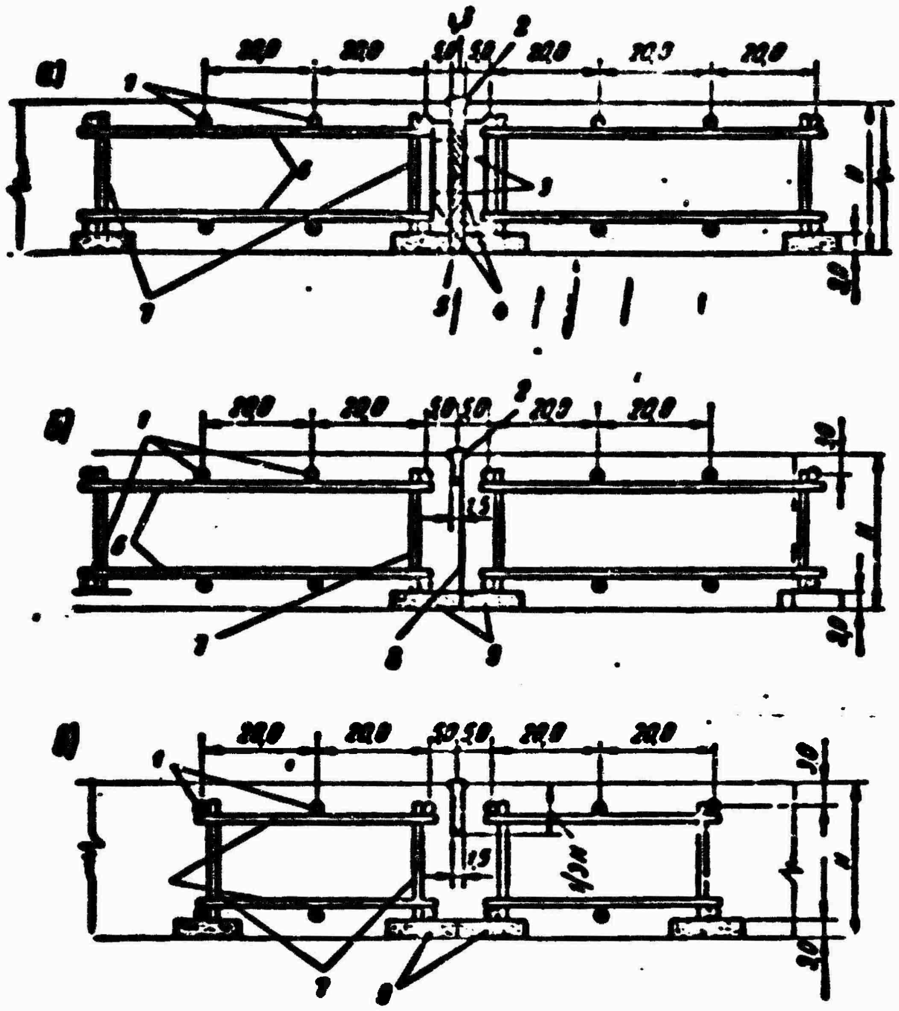


Fig. 88. Scheme of reinforcing edge sections of slabs at through joint. a) Expansion joint with wooden filler; b) compression joint; c) dummy joint; 1) working reinforcements 12-14 mm in diameter; 2) bitumen mastic; 3) nails; 4) wooden girders 4 x 1 cm I = II = 1 cm) each 100 cm; 5) board filler δ = 1.5 cm; 6) installation reinforcements 6 mm in diameter; 7) installation reinforcements 3 mm in diameter; 8) bitumen layer 1-1.5 mm; 9) concrete supports 10 x 10 x 3 cm.

Cages are produced at a typical reinforcements yard, which should be located as close to the section at which they are placed as possible.

The reinforcements yard consists of a platform for unloading and sorting of reinforcements; a shed for storing the reinforcement materials; an area for stretching, cleaning, cutting and bending the reinforcement; a warehouse of produced working and installation reinforcements; a shop with jigs for welding the lower meshes and a shop with jigs for welding the upper meshes; a shop for welding of cages and a finished cages warehouse.

Welding of meshes and cages is the most labor consuming process.

Construction of one cage with dimensions of 6.76 x 6.76 meters requires on the average up to 3000 welding operations. Reinforcement meshes are welded by special automatic welding machines gy the contact method, which eliminate burning of the reinforcements. The mesh and cage rods should be welded at points of intersection provided for in the plan.

Welding of the reinforcements at the point of intersection of rods, moving the welding apparatus to the following intersection of rods, moving the mesh through a single lead of the reinforcements and release of the following rod from the bin is done automatically in these machines. The machine wells a mesh up to 7 meters wide and of unlimited length. The productivity of the machine is up to 45,000 welded points per shift.

Reinforcement cage meshes produced by welding automatic machines are removed and transported to a jig in which they are welded into a cage by electric arc welding and then are transported to the point of placing or to the warehouse.

The reinforcements yard is serviced by 20 workers. Thr productivity of the brigade is up to 15 cages per shift in the winter with the premises enclosed and up to 25 cages per shift in the summer.

Th cages are transported from the reinforcements yard to the point of placing by trucks specially equipped for this purpose. In order to prevent bending, only 3 cages are loaded onto such a truck. The cages can be loaded by a truck or tower crane; here the cages loaded are not fastened to the frame or tied one to the other, since they are held together by friction and coupling.

The cages are transported over the approach roads together with other transports, but on the condition that the road width be not less than 10 meters. If the width is less than that, they are hauled over specially prepared temporary roads.

Before placing the reinforcing cages into the timber molds, concrete supports with dimensions of 10 x 10 x 3 cm are placed on the previously prepared foundation (Fig. 89).

The following is the order in which the reinforcing cages are placed in the timber molds: the truck with the cages drives up to the mold section prepared for placing the reinforcements, along which a truck crane with a lifting capacity of not less than 5 tons is placed; the rigging man, using a universal strap made from 6-10 cables couples up the cage which is then delivered into the timber molds.

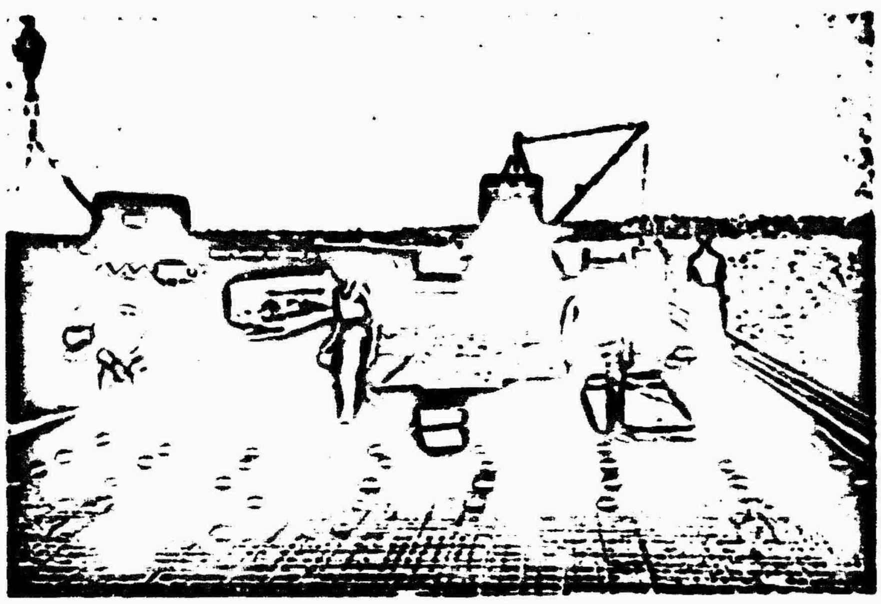


Fig. 89. Placing the concrete supports.

In lifting the cages bends slightly creating an upward concavity. By vitrue of this the width dimensions of the cage decrease slightly, this making possible convenient placing of the cage into the prepared mold. Rapid placing of the cage without the creation of a moderate transverse bent is practically impossible.

In order to place thr following cage both machine move through one slab length in the concrete placing direction. Every 3-4 slabs a board for constructing a transverse through expansion joint is placed between the cages. For stability the board is held rigidly by two thrust beams placed at both sides each 100 cm and it is tied with soft wire to

the cage (see Fig. 88). Transverse compression joints are constructed in a manner similar to dummy joints.

In reinforcing concrete pavements at weak sections it is possible to use welded rolled reinforcement mesh which is fabricated at plants from thin strong wire 5 mm in cross section with hole 10 cm in size in the longitudinal direction and 20 cm in the transverse direction. In this case the welded mesh is cut off to the required width. In twin-layer pavements the mes is placed on the lower pavement layer, and in reinforcing single-layer pavements it is placed at the design height on a layer made from fresh concrete mix.

52. REQUIREMENTS TO CONCRETE AND MATERIALS MAKING UP THE CEMENT CONCRETE MIX

Requirements Put to the Concrete

Dense, heavy, frost resistant concrete with a long service life possesing high compression and tension strength in bending should be used for concrete airport pavements1 Starting with January 1958 the construction of concrete and reinforced concrete airport pavements is covered by GOST 8424-57. The concrete is subdivided into brands by the 28 day strenght in compression and benaing. (Table 28).

TABLE 28

Назначение бетона 1	2 Марка бетона	
	3 при изгибе	4 при сжатии
Однослойное покрытие и верхний слой двухслойного покрытия 5	45, 50, 55	300, 350, 400
Нижний слой двухслойного покрытия 6	35, 40, 45	200, 250, 300
Для оснований 7	25, 35, 40	150, 200, 250

1) Purpose of concrete; 2) concrete brand; 3) in bending; 4) in compression; 5) single-layer pavement and upper layer of twin-layer pavement; 6) lower layer of twin-layer pavement; 7) for foundations.

Concrete whose brand is heigher than 55 in bending and higher than 400 in compression may be used in constructing pavements if this

is substantiated by technical and economic considerations.

The concrete composition is chosen not only on strenght considerations, but also taking into account the fact that the mix be conveniently transported and placed into the pavement.

A difference is made between rigid, plastic and flowing concrete mix, depending on the mobility and placing convenience. Pavements are best constructed from rigid concrete mixes, although they compact with difficulty and are difficult to place. The water to cement ratio of concrete mix placed in the pavement should be taken as not more than 0.5, and for placing in pavement foundations it should not be higher than 0.7.

Heavy concrete with specific weight within the limits of 2400-2500 kg/meter^3 should be used for concrete and reinforced concrete airport pavements. The cement consumption for single layer pavements and for the upper layers of twin-layer pavement should be not lower than 300 kg/meter^3 of concrete when the cement brand is not lower than 500; it should be 270 kg/meter^2 of cement whose brand is not lower than 300 for the lower layer of twin-layer pavements, and not less than 200 kg/meter^3 for pavement foundations.

Requirements to Concrete Constituents

According to GOST 8424-57, materials used for preparing the concrete mix must be of high quality and satisfy the following requirements.

Cement. For preparing the concrete mix use is made of high strength portland cement and also of its special kinds (hydrophobic, plasticized, etc.). The cement should not contain inert or active additives, with the exception of additions of up to 15% of ground granulated blast furnace slag. It is recommended to use alite aluminum ferrite cements with tricalcium aluminate content not higher than 10%.

To decrease the consumption use should be made of new special kinds of cement with the following positive properties.

Concrete mix made with plasticized portland cement has increased mobility and ease of placing and the cement proper improves the frost resistance of the concrete.

This cement is obtained from finely ground clinker (portland cement) together with plasticizing additives (sulphite alcohol residue). The plasticized portland cements are divided by their strength into brands 300, 400, 500 and 600. The high placeability of concrete mix made with plasticized portland cement makes it possible to lower the water-cement ratio and by virtue of the same foact to lower the cement consumption up to 10%.

Hydrophobic (water repelling) cement is less subceptible to water wetting. The hydrophobic additive added during grinding of the clinker creates a thin shell on the surface of the cement particles preventing wetting the cemetn by water. This shell prevents settling of the cement, and on prolonged storage even in a moist air surroundings the cement activity does not decrease (ordinary portland cement loses 5-8% of its activity per month even if stored in dry surroundings). The non-wetting shell of hydrophobic portland cement breaks down in the process of concrete preparation and increases the plasticity and placeability of the concrete mix. The water requirement of the mix decreases (the water-cement ratio at the given placeability and movability of the mix decreases). To free the cement particles from hydrophobic shells the time required for mixing the cement mix is increased by a factor of 1.5. Hydrophobic portland cement is divided into brands 200, 250, 300, 400, 500 and 600.

Cement is stored separately by kinds and brands. Hydrophobic cement is convenient in storing, especially in constructing airports in

far removed North regions and in regions with excessive moisture.

Cement batches supplied to the construction site must be accompanied by a document listing the main characteristics of the cement (kind, brand, composition, etc.), and data about tests of specimens. Regardless of this document, each accepted cement batch should be tested before use for strength and setting time (the cement should start setting not earlier than 2 hours after mixing).

Rules for accepting the cement, taking of samples, testing methods and storage procedures are implemented in accordance with the requirements of the Technical Specifications for Performance and Acceptance of Airport Construction Operations (SN 121-60).

The results of testing the cement in a construction object at the construction site laboratory are accepted as the basis. When ordinary portland cement is stored in warehouses for more than 3 months it should be retested.

Crushed stone and gravel. Crushed stone (gravel) is used as the coarse filler in concrete. Only crushed stone is used as the coarse filler in single layer pavements and in the upper layer of twin-layer pavements, with the use of gravel permitted for constructing concrete foundations and for the lower layer of twin-layer pavements.

The greatest grain size for crushed stone (gravel) is established as 70 mm for foundations, 60 mm for the lower layer of twin-layer pavements and as 40 mm for the upper layer of twin-layer and for single-layer pavements. The use of finer crushed for concrete pavements results in obtaining a more even pavement, facilitates the construction of temperature joints and increases the quality and uniformity of the concrete. The crushed stone (gravel) should not contain lammelar fractions in an amount more than 15% by weight.

In order to ensure constancy of the grain size distribution and

homogeneity of the concrete mix, the crushed stone (gravel) should be divided into the following fractions with subsequent separate proportioning:

for maximum grain size of 60 mm it should be divided into fractions with grain sizes of 20-40 and 40-60 mm;

for maximum grain size of 40 mm it should be divided into fractions with grain sizes of 5-20 and 20-40 mm.

It is permissible to use crushed stone (gravel) for foundations with grain sizes from 5 to 70 mm without separating into fractions. GOST 8424-57 has increased the requirements put to the concrete coarse aggregate with respect to strength and frost resistance. The ultimate strength for coarse aggregate for single layer pavements and for the upper layer of twin-layer pavements should not be lower than 1200 kg/cm^2 for igneous rock and not less than 800 kg/cm^2 for sedimentary rock; for the lower layer of twin-layer pavements it should be not lower than 800 kg/cm^2 for igneous rock and not less than 600 kg/cm^2 for sedimentary rock.

Requirements put to the frost resistance of crushed stone and gravel depending on the character of the pavement design and on the climate are presented in Table 29.

Climatic conditions are characterized by the average mothly temperature $\underline{t}$ of the coldest month and the number $\underline{n}$ of freezing and thawing changes during the year. These quantities should have the following values:

For severe climatic conditions	$\underline{t}$ below -15°, $\underline{n}$ not lower than 50
For moderate climatic conditions	$\underline{t}$ from -5 to -15°, $\underline{n}$ from 20 to 50
" mild " "	$\underline{t}$ to -5°, $\underline{n}$ less than 20.

For better cohesion with the cement the stone material should be

TABLE 29

Вид покрытия 1	Климатические условия 2	Требуемая морозостойкость (Мрз) щебня и гравия при испытании 3			
		непосредственным замораживанием 4		в растворе сернокислого натрия 5	
		число циклов 6	потеря в весе, %, не более 7	число циклов 6	потеря в весе, %, не более 7
8 Однослойные и верхний слой двухслойных бетонных покрытий	Суровые 9	150	5	15	5
	Умеренные 10	100	5	10	5
	Мягкие 11	50	5	10	10
12 Нижний слой двухслойных бетонных покрытий	Суровые 9	50	5	10	10
	Умеренные 10	25	10	5	10
	Мягкие 11	15	10	3	10

Note: 1. When the water absorption of igneous rock for crushed stone and also of gravel is lower than 0.5% and of sedimentary rock it is lower than 1%, no frost resistance tests are performed. 2. In the case that unsatisfactory results are obtained in testing in a sodium sulfate solution the material is retested directly by freezing. The results of this test are decisive.

1) Kind of pavement; 2) climatic conditions; 3) required frost resistance (Mrz) of crushed stone and gravel in testing; 4) by direct freezing; 5) in a sodium sulfate solution; 6) number of cycles; 7) weight loss, %, not more than; 8) single layer and the upper layer of twin-layer concretepavements; 9) severe; 10) moderate; 11) mild; 12) lower layer of twin-layer concrete pavements.

sharp edged in shape and should have a rough surface. The clay and dust particle content should not exceed 1% in crushed stone and 2% in gravel by weight.

Sand. Sand serves as fine filler in the concrete with grain size from 0.15 to 5 mm.

The GOST provides for the use of coarse, medium, fine and extra fine sand for mixing of concrete, which makes it possible to extensively use the local sand. To save cement and to increase the strength of the concrete the use of fine grained sand is permitted only with the

TABLE 30

Примеси a	Для бетона однослойных покрытий и верхнего слоя двухслойных покрытий b	Для нижнего слоя двухслойных покрытий c
Глинистые, илистые и пылевидные частицы, определяемые отмучиванием, % по весу d	3	5
В том числе глины, % по весу e	1	2
Органические примеси, определяемые методом окрашивания f	g Окраска не темнее эталона по действующему стандарту на методы испытаний песка	
Слюда, % по весу h	1	2

a) Admixtures; b) for concrete for single-layer pavements and for the upper layer of twin-layer pavements; c) for the lower layer of twin-layer pavements; d) clay, muddy and dusty particles determined by sedimentation, % by weight; e) including clay, % by weight; f) organic admixtures, determined by the coloring method; g) the color should not be darker than the sample established by the sand testing methods standard in force; h) mica, % by weight.

addition of a certain amount of coarser sand (the amount of coarse sand to be added is determined from sieve curves) or of surface-action organic additives (sulfate alcohol residues, abietic resin, etc.). In order to ensure high frost resistance, strength and uniformity of the concrete, the sand should satisfy the following requirements: it should not contain gravel or crushed stone grains with sizes larger than 10 mm, and content of grains from 5 to 10 mm in size is permitted in the amount of not more than 10% of the sand by weight; the amount of admixtures in the sand should not exceed the values given in Table 30.

Water. Any water (even salt water of the Black, Caspian and Baltic seas) is suitable for preparing of the concrete mix, sprinkling and washing of the concrete components, provided that it does not contain acids, alkalies, fats and other admixtures; here its pH should be not lower than 4, and the total content of soluble salts should not exceed 5000 milligrams/liter.

53. PREPARING AND TRANSPORTING OF THE CEMENT CONCRETE MIX

In constructing airports the cement concrete mix can be prepared

in standard prefabricated automated, semiautomated or mechanized continuous or intermittent action plants with concrete mixer capacities of 1200 and 2400 liters (Fig. 90).

The selection of the concrete plant and its productivity is determined in accordance with the rate of the concrete placing operations, the set of concrete placing machines used and the weight carrying capacity of the dump trucks.

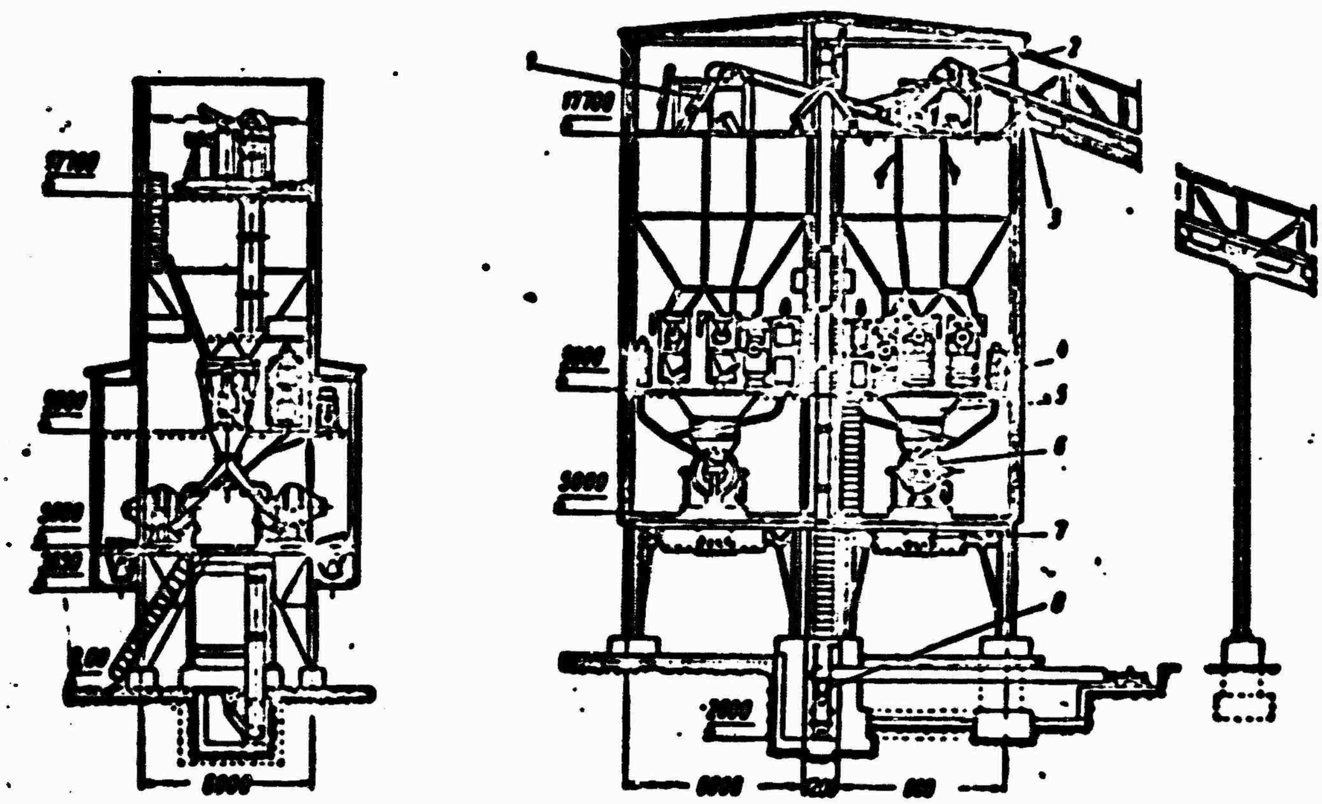


Fig. 90. Standard concrete plant with four concrete mixers, 1200 liters capacity each. 1) Rotary funnel of the second section; 2) feeding conveyer; 3) belt conveyer; 4) batching plant; 5) loading device; 6) concrete mixer; 7) distributing bin; 8) belt elevator for cement.

When using the D-181V spreader for placing of concrete use should be made of an automated concrete plant with two 1200 liter capacity concrete mixers with the concrete mix transported by ZIL-585 dump trucks. In this case the productivity of the entire set of machines used will be coordinated. If the new D-375 spreader is used for placing together with dump trucks with side unloading (DAZ-600 or MAZ-506), then use should be made of a concrete plant for preparing rigid con-

crete mixes in forced action concrete mixers. To obtain a homogeneous concrete mix special care should be taken to conform to the time for mixing and the ratio of components making up the mix, specified by the construction site laboratoru.

The proportioning section of the concrete plant should have the specified concrete composition for the given shift and the plant's laboratory should daily control the quality of the received material, introduce corrections to the batching, control the mixes produced and the concrete strength. Batching of concrete components should be by weight only with deviations of the established water and cement proportions of $\pm$ 1.5%, of sand 2% and of crushed stone or gravel $\pm$3%.

The operation of batching devices should be checked daily and at the begining of shift.

Lately the IChZ-5 special device installed in the batching section of the plant is used for choosing an economical concrete composition of the given brand and for controling its preparation, which gives a cement saving of up to 10%.

In order to prevent dusting and sticking of cement to the concrete mixer walls, its drum is first loaded with crushed stone and water, then by cement and immediately thereafter by sand. The time for mixing from the instant of loading of all materials into the drum to the begining of unloading should comprise 120 seconds for 1200 liter concrete mixers and 150 seconds for 2400 liter concrete mixers.

At the end of each shift the concrete mixer drums are thoroughly cleaned and washed with water.

The organization of transporting the cement concrete mix from the concrete plant to the place of placing should satisfy the following requirements:

the concrete mix must be protected from leakage, drying out, sett-

ling into layers, contamination and premature setting;

the productivity of the transportation facilities should correspond to the productivity of the concrete plant and to the concrete pouring rate.

The cement concrete mix separates into layers due to bumps and shakes when transported over poor roads, for which reason the temporary approach roads should be constantly maintained in good order. Previously placed rows of concrete pavement should (whenever possible) be put to maximum use as hauling routes.

To protect from drying out and from rain for a hauling duration of more than 20 minutes the cement concrete mix must be covered by tarpaulins, while in the winter it must be covered by insulating material to prevent it from freeaing. The number of required dump trucks is determined by calculation. The bodies of the dump trucks should be clean and in proper condition (protecting the mix from leakage).

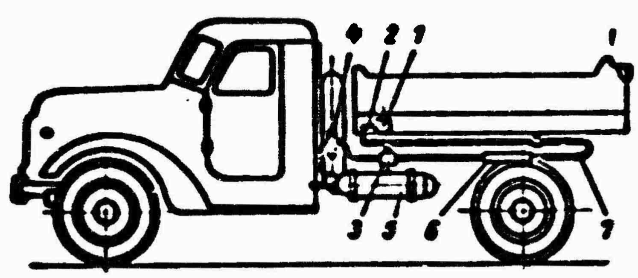


Fig. 91. Pneumatic vibrators on the body of the ZIL-585 dump truck. 1) Vibrator; 2,4 and 7 rubber hoses; 3) automatic crane; 5) receiver; 6) lubricating mechanism.

To prevent the concrete mix from sticking to the walls and bottom of the dump truck body, the body must be thoroughly washed with water every 3-4 hours of operation as well as at the begining and end of a shift at a washing point near the concrete plant. To accelerate unloading and to decrease losses of the cement concrete mix, pneumatic vibrators should be installed on the dump trucks (Fig. 91).

The hauling duration of a cement concrete mix whose setting time

is 2 hours should not exceed 1 hour and 30 minutes for an air temperature up to 15°. 1 hour for a temperature from 15 to 25° and 30 minutes for a temperature above 25°.

54. PLACING THE CEMENT CONCRETE MIX

Before the cement concrete mix is placed the following must be thoroughly checked: proper positioning of the paving forms, timber molds, reinforcing cages and elements of butt joints; proper density and moisture content of the prepared foundation; quality of timber mold libricatlon and placement of water resistant paper on the foundation (if this is provided for in the plan); proper position and fastening of spacers in joints; quality of bitumen application to the tongue of the tongue and groove joints in previously poured concrete slabs; the state of temporary approach roads; good operating order of the set of concrete placing machines and their adjustment; availability of various auxiliary tools or equipment for placing, compacting the mix, finishing the surface, construction of joints and curing the cement concrete.

Concrete pouring cannot start before checking the quality of all the preceding preparatory work.

The first process in placing the cement concrete mix is its spreading the the D-181 bin spreader. In order to spread the cement concrete mix over the foundation in an uniform layer of the specified thickness the spreader is adjusted before the start of work experimentally, taking into account settling of up to 10-12% on compaction.

The spreading accuracy with respect to thickness is obtained by a pilot wheel which changes the position of the bin frame. The second important consideration in adjusting the spreader is placing the end supports of the bin in a position in which the mix is spread all the way to the internal walls of the paving forms. The bin spreader can also be used to place the cement concrete mix in the gutter sections of the

pavement. For this purpose two pairs of wedge shaped plates, conforming to the gutter profile are fastened to the guiding beams over which the bin rollers move.

The dump trucks drive up to the spreader whose bucket is raised from the side of the trench or finished pavement. After the dump truck pass the spreader bucket is lowered and the mix is unloaded into it. The bin-type spreader volume is 1.6 meters^3 which corresponds to the capacity of the ZIL-585 dump truck. Then the dump truck drives away without turning around and the bucket is raised by a winch and the mix is unloaded into the spreading bin with a collapsible bottom. The cement concrete mix is distributed in even strips up to 0.9 to total strip depth. After spreading the mix on the strip the next cycle starts with moving the entire D-181V machine by 0.7-0.9 meters. The average duration of the cycle is 2-3 mimutes. The bucket should be raised when the machine is moved. The position of the reinforcement cages and of the butt joint elements should be kept intack during spreading the mix.

The spreader is serviced by 3 workers (the operator, his helper and one auxiliary worker.

The productivity of the spreader is 25-30 meters^3/hour, which corresponds to the productivity of a standard automated concrete plant with two 1200 liter concrete mixers.

In comparison with the D-181V spreader, the D-375 self-propelled bin-type spreader is more refined (Fig. 92). It makes it possible to load the concrete mix into the spreader bin from both sides, has twice the productivity, does not have a lifting bucket, only a bin spreader with 2.4 meters^3 capacity.

The D-375 machine has been designed for work with dump trucks with side unloading.

The MAZ-506 dump trucks with a 5.5 ton lifting capacity whose

body unloads on both sides are most dfficiently used with the D-375. The MAZ-506 is loaded by three 1200 liter concrete mix batches, which makes it possible to completely utilize the capacity of the bin spreader and to ensure uniform spreading of the mix. In addition, the dumping height of the MAZ-506 dump truck is about 130 cm, which makes it possible to unload the concrete mix from the soil trench or sand foundation of an adjacent strip without cumbersom approach ramps.

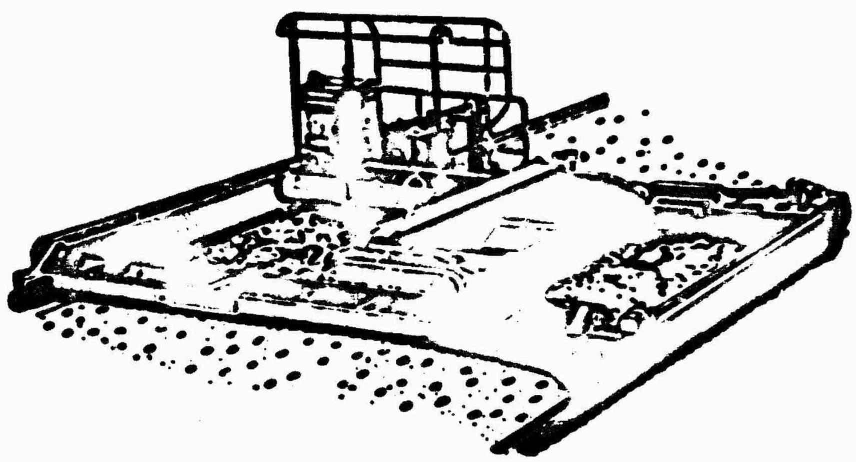


Fig. 92. The D-375 bin-type concrete mix spreader.

Normal operation of the D-375 spreader requires the adaption of a new standard concrete plant with a productivity of up to 50 meters^3/ hour, which could prepare rigid concrete mixes, for which the new spreader has been designed.

Preparing of rigid concrete mixes in type S-221 concrete mixers with 1200 liter capacity requires increasing the mixing duration by a factor of 2-3 in comparison with preaparing of plastic concretes, which results in sharply decreasing their productivity.

The D-375 spreader is designed for spreading concrete in one or two layers from 8 to 50 cm thick with strip widths of 3.5, 5 and 7 m.

The accuracy of spreading the concrete mix by the D-375 spreader depends on carefully adjusting it, which is performed before the work starts and during the work by trial and error. Proper selection of the

pavement thickness taking into account settling due to compaction is achieved by simultaneous trial and error adjustment of the working elements of the spreader and of the vibrating finishing machine.

In constructing twin-layer cement concrete and single layer reinforced concrete pavements reinforced by a single mesh in the middle with continuous pouring it is necessary to ensure precise coordination of the processes of placing the lower and upper layers. In this case two D-375 spreaders are used for spreading the cement concrete mix. The distance between the two spreaders should ensure concenience and safety of the mix spreading operations, but should not exceed 15-20 meters. The concrete mix may not be placed into the upper layer when setting has started in the lower layer. The time interval between spreading of the cement concrete mix of the lower and upper layers depends on the air temperature and on the concrete composition and should not exceed the folloeing values.:

Above zero air temperature, degrees	Time interval, hours
up to 15	3
15-20	2
25-30	1

The cement concrete mix of the lower layer should be compacted by the vibrating tamper of the D-376 concrete finisher, lowered below the edges of the paving forms. The surface of the lower layer is not smoothened. The cement concrete mix in the upper layer is compacted and finished in the same manner as in single layer pavements.

55. COMPACTING OF CEMENT CONCRETE MIX AND FINISHING OF THE PAVEMENT SURFACE

Compacting the placed concrete mix and finishing the pavement are the most critical operations which determine the strength and quality of the future pavement. Thses operations are performed either by the D-

182V or by by D-376 machine.

The D-182V concrete finisher compacts the concrete mix placed in a layer of up to 30 cm and finishes the pavement surface in 2-3 passes. The main working elements of the D-k82V are the vibrating tamper, the screed and thefinishing belt (Fig. 93).

In the first pass the vibrating tamper is positioned by 2-3 cm heigher than the screed, the machine movers in the first gear. All working elements, except dor the finishing belt are in operation. The vibrating tamper has 5 I-117 vibrators and the screed has 3 I-7 vibators.

To obtain a level and strong pavement surface extreme care must be taken that, in the operation of the D-182V concrete finisher, a constant longitudinal pile of the mix 5-10 cm high be always pushed ahead by the vibrating tamper over the entire width of the pavement, with a similar pile 3-5 cm high pushed ahead of the screed.

In the second pass the vibrating tamper is placed at the level of the rail tips; the same working elements are in operation as in the first pass.

The third pass is made in the first gear with all the working elements, including the finishing belt, switched on. The surface is compacted and finished in section lengths of up to 20 meters.

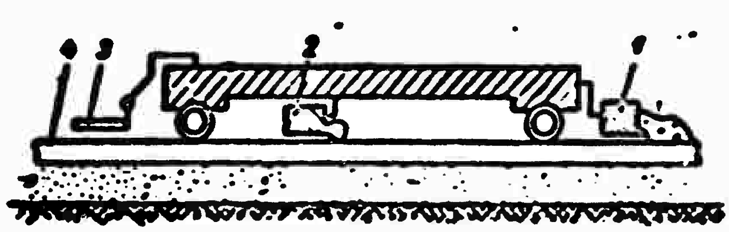


Fig. 93. Diagram of the D-182V concrete finisher. 1) Vibrating tamper; 2) screed; 3) finishing belt; 4) paving form.

The concrete finisher is serviced by 5 workers: the operator, his helper and 3 aùxiliary workers equiped with depth vibrators by which

they additionally compact the concrete mix placed at the slab edges along the timber molds and near the transverse expansion joints, and if necessary they cut off excessive comcrete mix or add to points in which it lacks on compacting.

After three passes of the D-182V machine additional finishing of the pavement surface is usually not required. If blowholes and uneven spots are still left on the pavement surface this points to poor work of the vibrators or to poor quality of the cement concrete mix. All the defects of the concrete pavement surface are corrected by hand, using smoothing tools, finishing belts and rubbing tools (Fig. 94) from a bridge moving on wheels. The use of water in surface finishing is prohibited.

The surface evennes is checked by a 3 meter rod placed in the longitudinal and transverse directions. The gap beneath the rod should not exceed 5 mm.

The D-376 concrete finisher is more refined (Fig. 95) than the D-182V.

The working elements of this machine are a vane shaft for final leveling of the cement concrete mix, vibrating tamper equipped with six mechanical vibrators and a finishing beam arranged together with a vibrating board.

The vibrating tamper compacts the concrete mix without supporting itself on the paving forms, which makes it possible to transfer a part of the weight of the machine proper through the vibrating tamper to the placed mix. In addition, the vibrating tamper is provided with a rocking mechanism, which imparts to it reciprocating motion.

The enumarated features make it possible to use the D-376 machines for compacting rigid concrete mixes with a layer thickness up to 50 cm by 1-2 passes over the same trace.

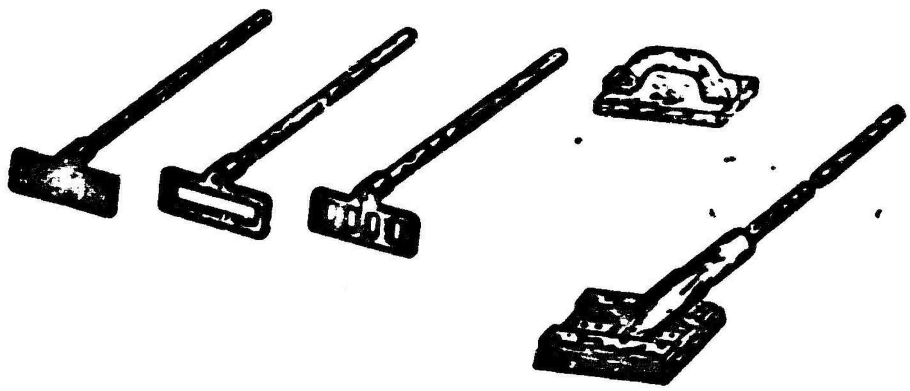


Fig. 94. Rubbing and smoothing tools for finishing the surface of placed concrete mix.

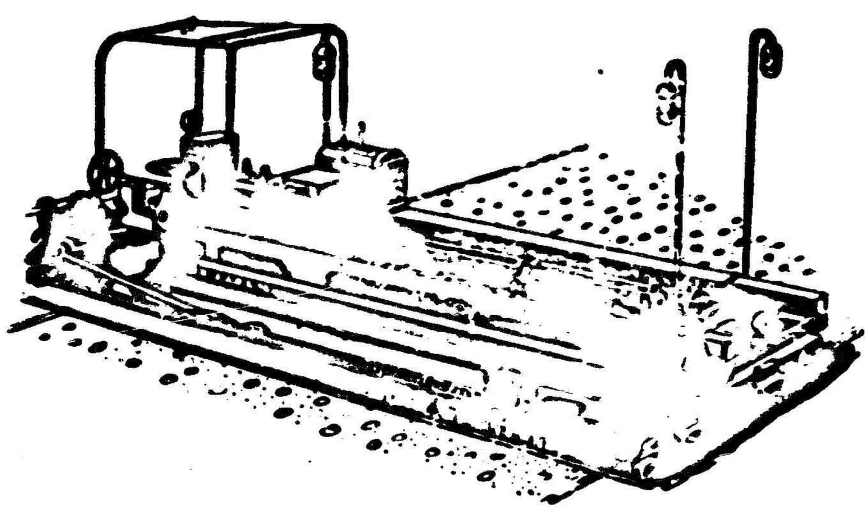


Fig. 95. The D-376 concrete finisher.

To obtain a quality pavement the D-376 concrete finisher is adjusted before its work starts:

1. The plane of the machine fram is, by changing the length of the pull rods, placed parrallel to the paving forms.

2. The vane shaft's height is adjusted by taking into account the concrete compaction.

3. The rear edge of the vibrating tamper is placed at the level of the paving form tops.

4. The lower edge of the vibrating board and the rear edge of the finishing beam should be parallel and then bottom of the finishing beam should have specified slide-on angle.

Signs attesting to proper adjustment of the working elements of the D-376 machine is theformation of a uniform roll of concrete mix 5-8 cm high ahead of the compacting vibrating tamper and of a roll of cement grout 1_2 cm high ahead of the finishing beam. The rolls are kept at uniform height in the process of operation by adjusting the compacting vibrating tamper and the vane shaft. After the first pass, if a large number of defects is left on the pavement surface, a second pass it made.

It has been established that the D-376 concrete finisher does not sufficiently process and finish the pavement surface made from rigid concrete mixes (W/C = 0.35-0.45). After 1-2 passes the pavement surface must be finished off by hand. In addition, the vane shaft pulls out coarse crushed stone fractions from the concrete mis and concentrates them on the pavement surface thus making difficult finishing it and disturbing the designed concrete structure.

The short base of the track wheels of the D-376 concrete finisher (about 1.5 meters) makes ensuring evennes of the constructed pavement in the longitudinal direction difficuly. All the irregularities in placing of the paving forms, especially sags at the joints, are reproduced on the pavement.

Lately, in order to ensure evennes of the airport pavements in the longitudinal direction a long-base additional concrete finisher (Fig. 96) is being included into the concrete placing set to be towed by the D-376.

Two vibrating tampers placed at a 90° angle are suspended from the machine's platforms. 4 mechanical vibrators are installed on each. The rear platform is provided by a 6.9 meter long finishing beam with a rubber belt. The machine is controlled by a hydraulic mechanism operated from a panel; the productivity for a concrete row width of 7 m is

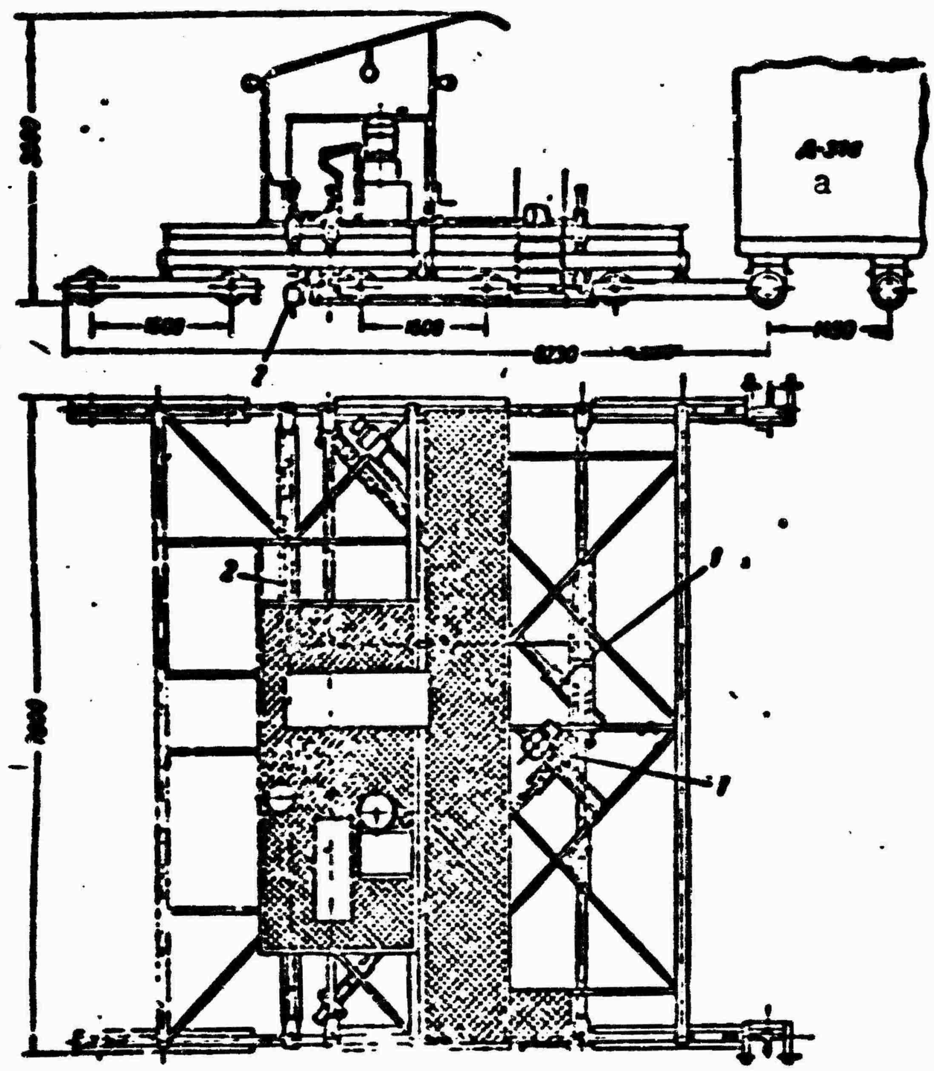


Fig. 96. Drawn, long base concrete finisher. 1) Vibrating tamper; 2) finishing beam equipped with a rubber belt; a) D.

up to 250 linear meters/shift.

All the concrete placing machines considered above move over the paving forms, the placing and removal of which are up to the present time most labor consuming and cannot be mechanized in an integrated manner. For this reason the D-502 concrete placer is now being adapted for constructing concrete road and airport pavements on sliding forms with a system of automatic control of all working elements.

The machine is equipped with a concrete spreader, screed and tamper, finishing beam and belt. The width of the concrete pavement strip constructed is 3.5 meters and the thickness is up to 28 cm. The placer moves over a compacted and leveled foundations on two crawlers at a

speed of about 1 meter/minute. The sliding steel forms, which replace the ordinary paving forms are 30 meters long. The use of a placer with sliding forms for constructing concrete pavements will make it possible to lower the amount of metal required for the set by a factor of more than 8, and the labor input required by a factor of 3.

To construct concrete pavements at junction points of runways and taxiways, taxiways with individual and group aprons, at hangar site areas, gutters and other places where it is either impossible or incovenient to use the basic concrete placing machines due to the small work volume, it is expedient to use a simplified type concrete finisher. This machine has a leveling blade and a vibrating tamper with three mechanical vibrators driven by the D-6/3 internal combustion engine with 6 HP rating. The machine moves over paving forms using a manual mechanism. The width of the constructed strip is 3.5 meters and the productivity is up to 20 meters^3/hour.

56. CONSTRUCTING THE JOINTS

Expansion and contraction joints in upper part of concrete pavements are the weakest structural elements. They are to the greatest extent subjected to the action of external loads (of aircraft) and atmospheric factors. The watertightness and service life of pavements during operation depends to a large extent on the quality of joint construction and of filling of the upper space of the joints. Up to recently the main method for constructing joint spaces is cutting them in freshly laid concrete by vibrating knives of the D-159V or D-377 joint sawing machines (Fig. 97).

Sawing of joints starts 10-15 minutes after compacting the concrete mix and final finishing of the pavement surface. Before sawing marks are made carefully on the paving forms or on the side of transverse joints by markers or by placing pegs with flags on both sides a-

gainst the joints. It must be kept in mind that if the gap does not coincide with the placed wooden spacer of the expansion joint (see Fig. 88) then this always results in random formation of cracks at the edges of joints cut and filled with mastic.

The D-377 machine is self-propelled and has a vibrating knife for cutting of transverse joints over the entire width of the pouted pavement strip and a composite vibrating disk for sawing of the longitudinal joint. In addition, the D-344 hand joint filling machine is mounted on it on a special guiding rail.

The transverse joint is sawed strictly according to marks made on the paving forms. The vibrating knife is first sinks by its own weight with the bibrators disconnected. Then the vibrators are switched on for 15-20 seconds in order to lower the knife to the design depth and to ensure better distribution of crushed stone particles in the concrete mix in the strip in which the joint is situated.

The knife is raised (retracted) slowly after the vibrators are disconnected. The longitudinal dummy joint is similarly cut by the vibrating disk moving along paving forms with the entire machine in the first gear. The disk is lowered to the joint cutting depth with the vibrated disconnected.

When the vibrating knife or disk is removed, a well planed and wooden spacer lubricated by spent lubricants or lime and produced with a slight taper (to facilitate its removal) is placed in the space thus formed. Crests with slopes to form facets with a rounding radius of 5-10 mm in the slab edges are nailed at eh upper part of the spacer. Metal spacers may be used instead of the wooden spacers.

After the spacers are placed in the sawed space the concrete mix at the gap edges is compacted by special vibrating templates (Fig. 98) until cement grout appears on the pavement surface.

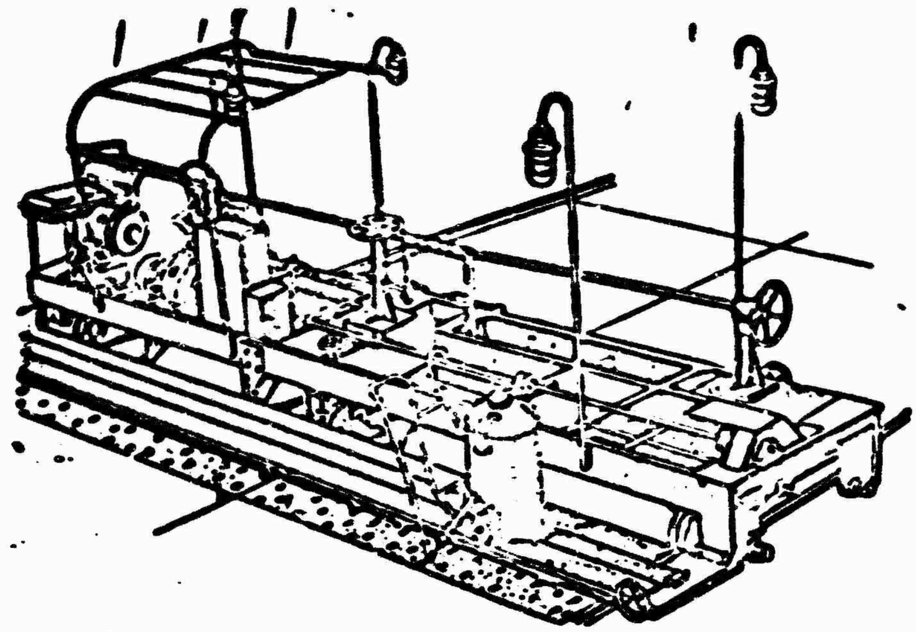


Fig. 97. The D-377 joint producting machine.

The time during which the spacers should be kept in the concrete is determined experimentally depending on the air temperature. The most important point is that the edges of adjacent slabs should not become raised after extracting the spacer and that the concrete walls of the joint should not flow and the pavement edges should not be damaged. After the spacers are removed all the defects in the joint are removed by smoothing tools and the joint is immediately filled by the TsN-2 or N-5 infusible mastic by the D-377 machine or from the D- 195V bridge.

The TsN-2 mastic consists of 24% of brand III bitumen, 56% of the V-1 alloy, 6% of serpentine asbestos and 14% of sand passed through a sieve with o.75 mm holes.

The N-5 mastic consists of 25% of brand III bitumen; 50% of the V-1 alloy and 25% of mineral powder.

Before filling the transverse joint the guiding rail over which the joint sealing device moves should be positiined by special screws so that the filling nozzle be exactly over the cut gaps over the entire joint width. The bitumen mastic should be heated to a temperature not lower than 160° and well mixed.

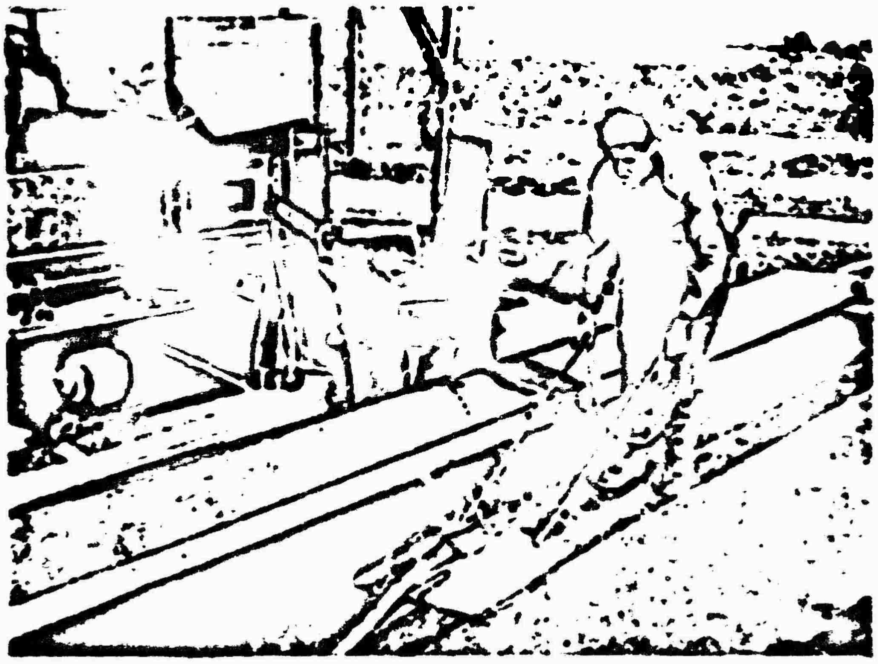


Fig. 98. Compacting of joints by a vibrating template.

Joints are sealed in two stages up to the top of the gap, without letting the mastic to flow out past the limits of the joint. The excess mastic on the joint is cut off after the concrete curing is completed. The longitudinal joints are sealed in the same manner by moving the entire machine forward.

Sealing of joints in freshly placed pavement slabs wnsures better cohesion between the mastic and the concrete by creating a vacuum on hardening and settling of the concrete mix. The mastic also protects the side surfaces of the joints from drying out thus creating conditions favorable for hardening of concrete at slab edges. However, in cutting of joints by a vibrating knife or disk in freshly placed, compacted and finished concrete the structural strength of the concrete at the slab edges is disturbed, and the displaced concrete produces undulations on the pavement. The joints then became ragged with uneven edges.

Attempting the produce even joints, the builders use various hand trowels, rubbing and smoothing tools for making of "splash on layers"

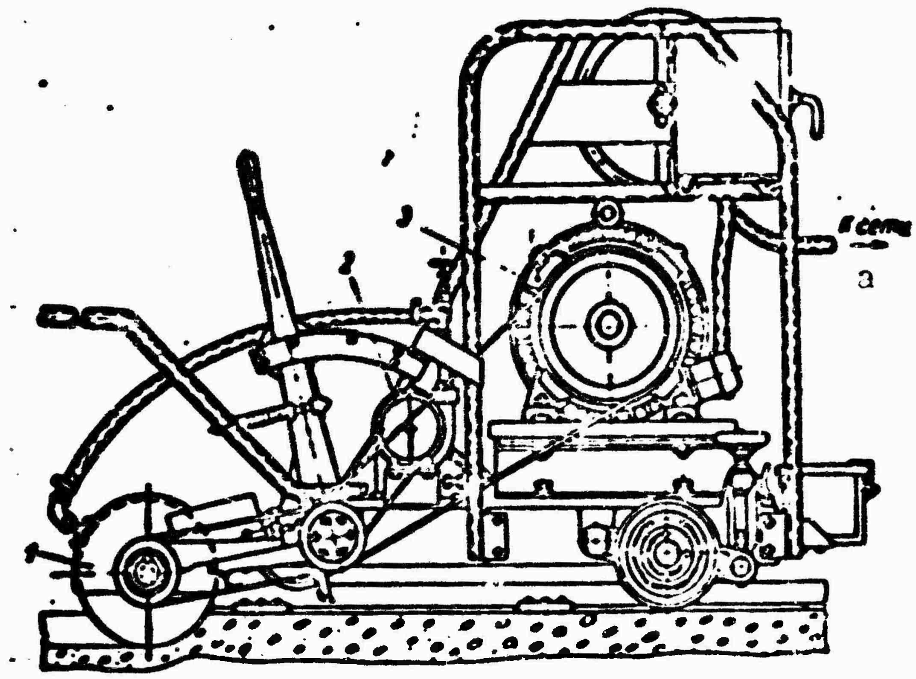


Fig. 99. Diagram of a single disk temperature joint sawing machine. 1) Cutting disk; 2) water pump; 3) electric motor; a) to the line.

on the slab edges.

At the present time special joint sawing machines, which cut joints in hardened concrete sawing apart the pavement by rapidly rotating abrasive cutting disks, are being adapted into the practice of construction of concrete and reinforced concrete road and airport pavements. The joints thus obtained are beautiful and have a long service life. The main virtues of this joint sawing method is the long life of the joints and its good external appearance; the pavement finishing process is simplified and the manual labor input is decreased several fold. Among the virtues we should also count the possibility of accelerating the begining of concrete curing after passing of the concrete finisher, which is especially important in hot sunny days and at subzero temperatures.

Starting with 1960, the Nikolayev Road Machine Plant serially produces the D-432 joint sawing machine (Fig. 99). The joint sawing machine is a cart on wheels moved by hand over guiding rails. The main

cutting working element is driven by an electric motor. The machine is equipped by a water pump supplying water to cool the abrasive disk. The machine is serviced by an operator and his helper.

The following are required for ensuring normal operation of this machine: abrasive cutting disks calculated as one disk per 20 linear meters of joint; portable electric generating set such as PES-100; portable water tank designed for a flow rate of 400-500 liters of water per hour. It is recommended that joints be sawed by the D-432 type machine at air temperatures of 15° 10-20 hours after finishing the pavement surface. At lower temperatures this interval is several days.

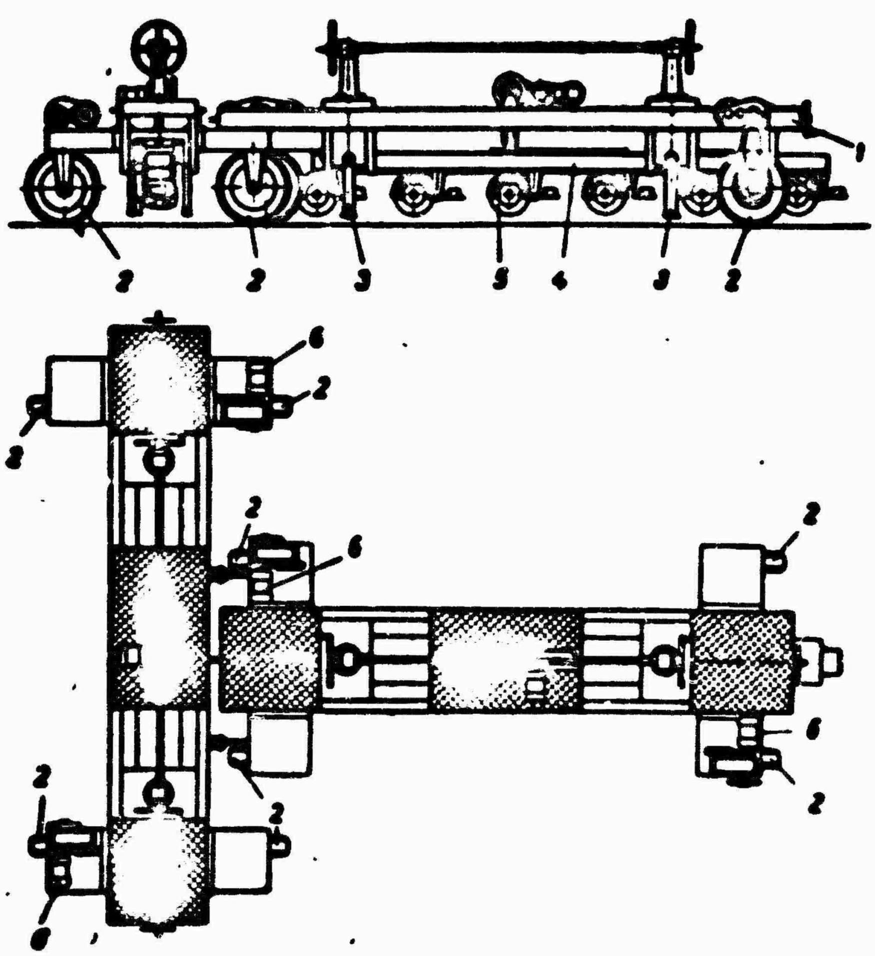


Fig. 100. Multidisk joint sawing machine. 1) Frame; 2) pneumatic-tired wheels; 3) suppot brackets; 4) portable cart with disks; 5) abrasive disks; 6) electric motor.

It was shown by analysis of the sawing of joints in hardened con-

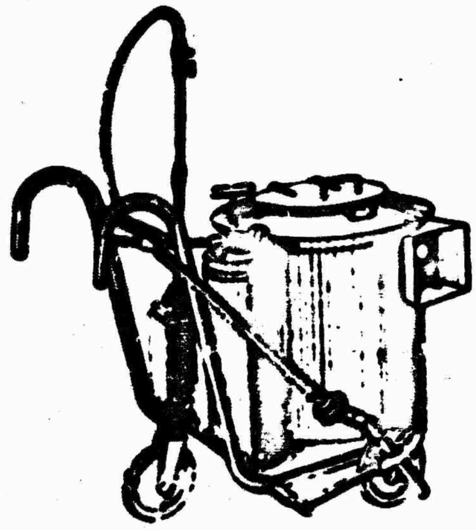


Fig. 101. The D-344 unit for sealing of joints with mastic.

crete that it can be lowered by using joint sawing machines with several cutting disks (Fig. 100).

Joints cut in hardened concrete are sealed by the D-344 hand sealing unit. Before sealing the joints should be cleared of dust, dried and lubricated by bitumen cutback. Matic for sealing of narrow joints 3-5 mm wide must be introduced into the joints under pressure (Fig. 101). After filling with mastic the joints are covered by material provided for by the cement concrete curing procedures.

57. CURING THE FRESHLY PLACED CONCRETE

In order to create favorable conditions for hardening, the conrete must be protected from wind and sun action, from being washed out by the rain, from mechanical shocks and impacts, from freezing and other factors until its strenght reaches at least 50% of the design strength. Curing of the concrete should start immediately after its surface has been finished.

The operational service life and stability of concrete pavements depend to a large extent on timely and proper organization of curing.

Sand (sprinkled with water), film forming materials,etc., may be used for curing the freshly placed concrete.

Curing of freshly laid concrete with the use of moistened sand is implemented in three stages.

The first stage of concrete curing starts immediately after sawing of joints and finishing the surface of the poured slabs and is terminated when the concrete begins to set. This instant is determined visually after moisture disappears form the pavement surface or by plac-

ing the palm of a hand against the pavement surface. The absence on the palm of stuck cement grout particles points to the fact that sand can be placed on the pavement surface without harming it.

At the first curing stage, in order to protect from the sun and wind and from creation of cracks, the pavement concrete surface is covered by light tents, shields, tarpaulines or by thin rolled watertight material, in order to minimize evaporation of water. It is better to use light tents whose frame is made from duraluminum tubes with union joints. Water repellent material is stretched on the frame. The entire tent is moved on wheels riding on the paving forms. Air circulation under the tent is not allowed. The main problem in the first concrete curing stage consists in stopping or slowing down the evaporation of water, in order to prevent the formation of settling cracks.

The second stage of concrete curing starts from the instant that moisture disappears from the concrete surface. In the second stage the cover is removed and a sand layer at least 6 cm thick is placed on the surface.

When no sufficient water is available for sprinkling and also in regions with a hot climate the sand layer is increased to 10-15 cm.

The sand is spread in a uniform layer through a rolling sieve in several applications. Practic has established the following procedure for covering the pavement with sand. First, using the rolling sieve a sand layer of 3-4 cm is carefully spread, which is immediately sprinkled with atomized water from a hose in the amount of 5-10 liters per 1 meter^2. Then, after 30-40 minutes the remaining part of the sand is spread, which is also sprinkled with an atomized water stream in the amount of from 20 to 40 liters per application. Then in dry weather when the air temperature is 30° the concrete is sprinkled during the day each 3 hours and at night each 5 hours, for at least 8-15 days af-

ter placing. The concrete sprinkling regime is more exactly determined by the construction site laboratory depending on the air temperature and humidity, the wind force and other factors.

Due to the large water requirement for concrete curing a temporary water pipeline should be constructed parallel to the pavement of the runway, taxiway or apron during construction. The concrete should be sprinkled by an atomized stream in order not to wash off the sand and thus bare the pavement. Thus concrete curing sequence prevents the formation of settling cracks.

The third stage of concrete curing starts after the sand cover is no longer sprinkled. In this time period the problem consists in protecting the concrete from rapid evaporation of moisture from it and from mechanical damage by transportation facilities. For this reason the sand cover is retained for 15 days after the sprinkling is discontinued. Special care should be taken not to leave the concrete during this period without the sand cover.

To protect the poured surface from mechanical damage and also to control the curing special signs are placed (Fig. 102) and a field book is kept about curing the concrete, in which data is recorded about the pouring time, curing schedule, about the weather conditions and also notations of persons perfaorming the checking.

In order to cure the concrete in the time it hardens use is made lately of special film producing materials (ethyne varnish, bitumen cutback, bitumen and tar emulsionsl).

Bitumen and tar emulsions consisting of 50-55% of bitumen or tar and of up to 3% of surface active substances (asidol to mixture of water-insoluble naphthenic acids, caustic soda, etc.), which promote uniforms distribution of the binder particles in water, are most economical and accessible for curing freshly placed concrete.

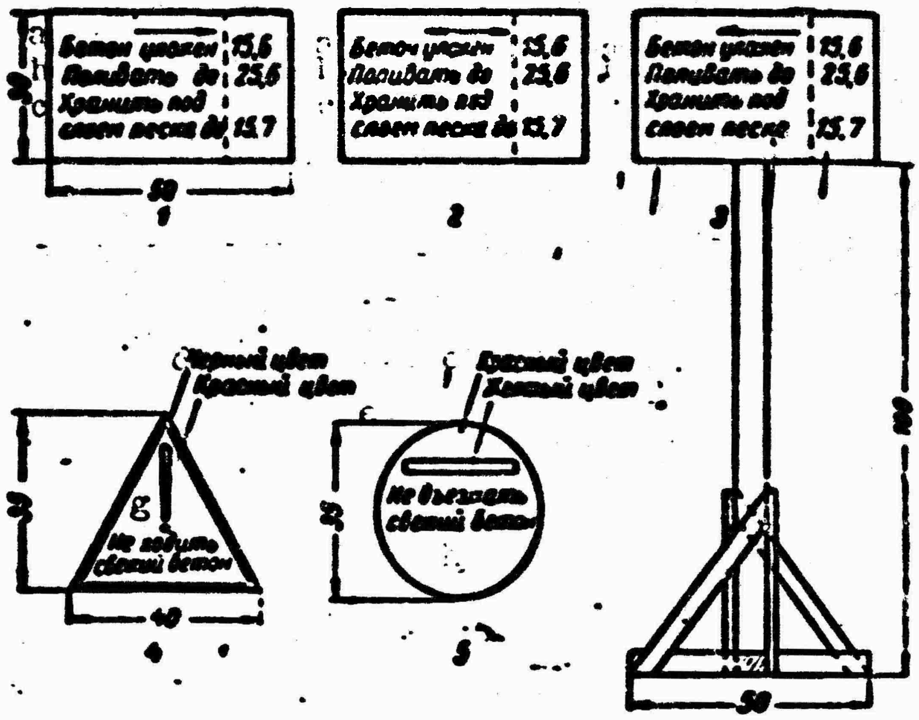


Fig. 102. Signs placed during curing of concrete. 1,2 and 3 are signs for control of the curing; 4 and 5 are for protect'ng from mechanical damage. a) Concrete placed; b) sprinkle up to; c) k ep under sand up to; d) black color; e) red color; f) yellow color; g) do not walk fresh concrete; h) do not drive fresh concrete.

The film forming materials are applied to the concrete pavement by special self-propelled spreading machines moving on the paving forms (Fig. 103). The first application is performed immediately after finishing the final compaction and surface finish work and after water has disappeared. Approximate application rates and the time for the second application after the first are given in Table 31.

Before the second layer is applied to the pavement it is recommended that the wooden or metal rods placed in joints should be removed, the joint edges finished and treated by film forming materials from a manual paint sprayer.

After applying the second layer of bitumen emulsion or bitumen cutgack the joints are sealed with mastic and the pavement is covered by a 5-6 cm sand layer or is whitewashed with lime in order to protect it from the sun's rays. Covering with sand or whitewashing with lime is performed at the instant of formation of a bitumen film (after the

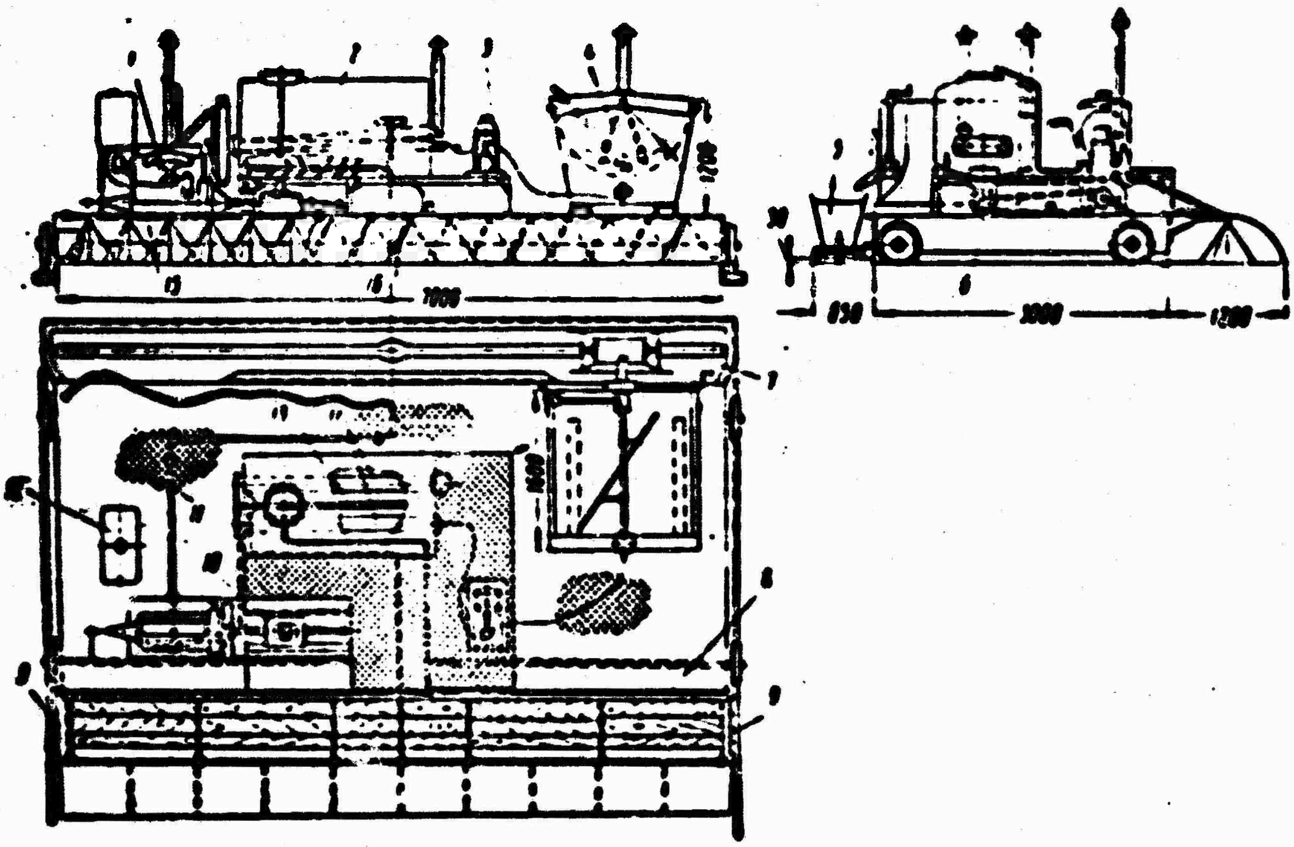


Fig. 103. Emulsion spreading machine with a multinozzle application pipe. 1) U-5MA engine; 2) emulsion tank; 3) pumping apparatus; 4) mixer-boiler for the mastic; 5) mastic cart; 6) UG-1M pump with distributor; 7) gangway platform; 8) circulation pipeline; 9) non-return valves; 10) ZIS-150 gear box; 11) gas pipeline; 12) fuel tank for the engine; 13) pipe for mixing the emulsion; 14) heating pipes; 15) distributing pipe; 16) speed reducer of the D-247 crane.

TABLE 31

Материал 1	Норма розлива, г/м² 2		Время нанесения второго слоя после первого, мин. (в зависимости от температуры воздуха) 3	
	первый слой 4	второй слой 5	при 15—20° 6	при 20—30° 6
Лак этиноль . . . 7	300	200	25	20
Быстрораспадающаяся битумная эмульсия . . 8	400	000	30	40
Медленнораспадающаяся битумная эмульсия . 9	400	300	40	30
Латекс синтетического каучука СКС-30 . . . 10 . . .	200	100	20	15
Жидкий битум (разжижитель—керосин или бензин) . 11 .	400	200	120—60	70—30
Дегтевая эмульсия . 12 . .	400	—	—	—

Notes. 1. The construction site laboratory may change the rate of application of film forming materials depending on the viscosity of the material used. 2. At outside air temperatures up to 15° the time after which the second application is made is increased by 10 minutes and at outside air temperatures higher than 30° it is decreased by 10 mins.

1) Material; 2) rate of application grams/meter^2; 3) time for applying the second layer after the first, min. (depending on the air temperature); 4) first layer; 5) second layer; 6) at; 7) ethyne varnish; 8) rapidly disintegrating bitumen emulsion; 9) slowly disintegrating bitumen emulsion; 10) SKS-30 synthethic rubber latex; 11) bitumen cutback (kerosene or gasolene used as the thinner); 12) tar emulsion.

58. PLACING OF CONCRETE INTO A PAVEMENT IN THE WINTER TIME

Pouring of concrete pavements in the winter at day temperatures below 5° and night temperatures below - 3° is performed by winter concrete pouring methods, since the process of concrete hardening and the increase in its strength practically ceases at below zero temperatures without heating up the ingredient materials. In order to ensure hardening of the concrete mix in cold weather calcium chloride and sodium chloride salts are introduced into it. Pavements constructed by the winter concrete pouring methods should satisfy the same requirements which are satisfied by pavements placed at above zero temperatures, and should have a concrete strenght at the instant of freezing not less than 30% of the design strength.

It is permissible to use concrete with increased salt admixtures at temperatures not lower than - 15° and in non-reinforced airport pavements. The quantity of salt is established by the construction site laboratory depending on the expected subzero temperature in the concrete when cured for the first 15 days after placing, but should not be higher than 12% of the water used for mixing.

Requirements to the Materials

Salts. Calcium chloride ($CaCl_2$) and sodium chloride (common salt NaCl) should be batched into the concrete mix as brine through water measuring tanks of the concrete plant's concrete mixers.

The brine is prepared at the concrete plant in a special solution producing unit (Fig. 104).

The composition of the salt solutions in water is specified by

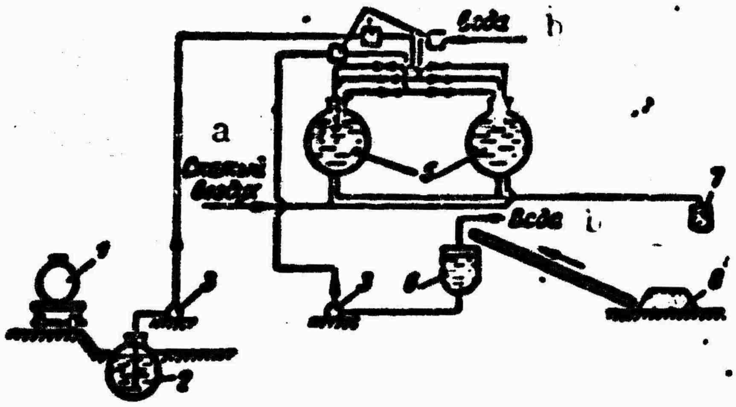


Fig. 104. Diagram showing the preparation of chloride salt solutions at a concrete plant. 1) Railroad tank; 2) calcium chloride solution; 3) pump; 4) proportioning units; 5) solution tank; 6) unit for producing the sodium chloride solution; 7) concrete plant batching unit; 8) calcium chloride storeroom; a) compressed air; b)water.

calculations with the following concentration being recommended:

a) increased concentration with a 3% content of calcium chloride and 5% content of sodium chloride for creating of a nonfreezing liquid ensuring hardening of concrete mix at temperatures up to -10°;

b) average concentration with a 3% content of calcium chloride and 5% content of sodium nitrate for creating a nonfreezing liquid ensuring hardening of the concrete mix at temperatures up to -8°;

c) moderate concentration with a 3% content of calcium chloride and 2% content of sodium nitrate for creating a nonfreezing liquid ensuring hardening of the concrete mix at temperatures up to $- 5^{\circ}$.

In order to increase the rate of dissolution of the salts, it is reconneded that the water in the solution unit should be heated to a temperature not higher than 85°. The volume of the prepared brine should not be less than that needed to provide for a shift of the concrete plant's work. The concentration and density of the obtained brine is controlled by an hydrometer.

Fillers. The sand should satisfy the technical specifications of the GOST 8424-57. The coarse (crushed stone or gravel) and fine (sand) aggregate should not contain lumps or snow or ice and of frozen par-

ticles of the material proper. If frozen sand, crushed stone or gravel lumps are present, the aggregate is passed through a roll crusher and passed through a sieve or screen which would remove frozen lumps coarser than 15 mm.

The surfaces of crushed stone particles or gravel grains may not be covered with ice.

The aggregate should be prepared in the fall in the warm time and should be stored in large piles in order to prevent freezing through and freezing together.

Aluminum oxide concrete may not be used.

Preparing and Transporting the Concrete Mix

The concrete mix is prepared in a mechanized manner at a heated concrete plant. A typical boiler room should be constructed at the concrete plant for heating it and heating up the water.

The water temperature is determined by sample mixes on the condition that the concrete mix temperature on placing should not be below zero and that rapid setting should not occur. Heated of water for the mix is practically unnecessary if the outside air temperature is up to -5°.

The foloowing sequence should be followed for loading of materials into the concrete mixer: the calculated salt solution is first poured in the heated state, then the coarse and fine aggregate is loaded and after they have been mixed for 1.5-2 minutes the cement is put in.

The time for mixing the concrete mix in the concrete mixer is increased by a factor of 1.5-2 in comparison with norms for the summer period and should comprise not less than 4 minutes. The mixing time is counted starting with the instant that all the materials are loaded into the concrete mixer.

The concrete mix can be supplied to the point of placing in un-

heated bodies of dump trucks, which are, however, protected from snow and from drying of the moisture by wind.

At outside air temperatures up to - 10° the concrete mix should be transported in heated dump trucks (insulation of the body, covering with shields and heating with the engine exhaust gasses).

The concrete mix should be placed into an unfrozen foundation, which is constructed under summer conditions not to the entire height. The upper layer of the foundation, not less than 10 cm thick, is constructed from dry or thawed sand immediately before placing the mix. Before pouring the paving forms and timber molds should be placed and all the preparatory work should be performed, as well as in placing the concrete mix, by a set of machines at above zero temperatures..

The concrete mix with an increase salt content also posses better placeability, for which reason is should be made rigid with the water-cement ratio not higher than 0.5.

Section for constructing the pavement by the set of machines are moderate (8-10 meters) in order to completely treat the placed mix in the shortest time possible and to prevent its freezing before placing of insulation. Longitudinal and transverse joints are sawed and sealed as usual, as at positive temperatures.

After placing, in order to prevent rapid cooling and loss of moisture, the placed mix is immediately covered by insulating materials. Dry sawdust, dry sand, moss or peat, slag and other materials are used as insulators.

In order not to damage the surface of the freshly placed concrete and to prevent rapid freezing out of the moisture, it is recommended that film producing substances, water repelling paper, tar roofing material, parchment and other rolled insulation materials be used as the first covering layer.

The thickness of the insulating materials is specified depending on the temperature at which the concrete mix was placed and on the insulating material, in order to ensure hardening of the concrete during the first 15 days after placing. At stable subzero temperatures it is permissible to use a snow layer up to 60 cm as the insulating material (as the upper layer after ordinary insulating materials have been placed in a layer of at least 5 cm).

The first cover should be placed carefully from the working bridge in order not to damage the pavement surface.

Constant checks must be made of the condition of the concrete cover.

The insulation is removed after the concrete has acquired the necessary strength. If the pavement is subject to becoming operational during the summer, then the insulation is left on it until above zero temperatures are reached whereupon the concrete curing is organized by the ordinary method.

The timber molds are removed after the concrete acquires at least 50% of its design strength (in bending and compression), but not earlier than a month after placing. The time for removing the timber forms is established by the laboratory on the basis of experimental data.

The control of the quality of concrete pouring operations under winter conditions must be especially through and systematic.

Control of the quality of materials used for constructing the foundation and preparing the concrete is mandatory. The moisture content of the sand and crushed stone and presence of frozen lumps in these materials is checked systematically.

The quality of the pavement trench and foundation is checked by the ordinary methods for compiling acts for filled over operations.

Pouring of concrete airport pavements in the winter time with addition of salt and heating of the component materials has not come into practical use due to large losses of heat in transporting and placing of concrete in a layer of moderate thickness.

56. CONTROLLING THE QUALITY OF WORK

Obtaining high quality concrete and reinforced concrete airport pavements requires thorough control of all operations, starting with checking the quality of materials supplied to the construction site and ending with concrete curing operations. The quality of work is controlled by the construction site laboratory and by quality control inspectors (mutual control between brigades and teams is being adapted).

The following production operations are subjected to mandato control which is reflected in acts for filled over operations or in control books:

finsish grading and compacting of the soil trench;

construction of the foundation, placing of paving forms and timber molda;

production and placing of reinforcements when constructing reinforced concrete pavements;

constructing the joints;

process of preparing the concrete mix and the quality of materials used;

placing of the concrete mix and finishing the pavement surface;

curing the concrete and sealing the joints;

control of the concrete strength of the quality of the finished pavement.

The strength is controlled by the construction site field laboratory and is determined by a series of control cubes (20 x 20 x 20 cm) and beams (15 x 15 x 55 cm) prepared simultaneously with placing of the

paveme[illegible] taking samples. The prepared series of specimens is tested after different time intervals. The number of control specimens subjected to prepartion and testing is given in Table 32.

The control specimens are kept before testing in a moist medium and are then subjected to bending, compression and freezing resistance tests.

The state of the pavement surface is checked by inspection in which the pavement undulations are exposed. The faces of adjoining sla slabs should be higher than one onother by more than 5 mm. The 28 day concrete strength should correspond to specifications: the permissible strength deviations should not exceed 10% on the low side when testing the specimens in bending and not more than 5% of the design strength and not more than 10% of the design compressive strength [sic].

The following are taken as the basis for estimating the quality of a finished concrete pavement:

Indicator No 1. Strength of the control specimens (the ultimate strength in bending and compression) and the density of the concrete mix.

Indicator No 2. Quality of joint sealing.

Indicator No 3. Evenness of the pavement surface.

The total estimate of the concrete pavement quality is given by indicators No. 1, 2 and 3. Pavements satisfying the requirements of design and technical specifications are given the following marks: "excellent" when indicators No 1 and 2 have been marked as "excellent" and indicator No 3 has been marked as "good"; "good" when indicators No 1 and 2 have been marked "good" and indicator No 3 has an at least "satisfactory" rating; and "satisfactory" when indicators 1, 2 and 3 are rated as at least "satisfactory" and the pavement does not have defects which make it impossible to accept it. When slabs with settling cracks are [illegible] the pavement is rated not higher than "satisfactory." Sett-

TABLE 32

Когда и от какого объема бетонной смеси берутся контрольные образцы 1	Способ хранения контрольных образцов 2	Количество контрольных образцов 3		Количество контрольных образцов, которые подвергаются испытаниям 4								Назначение испытаний 5
				в возрасте 7 суток на прочность 6		в возрасте 28 суток 7						
						на прочность 8		на морозостойкость 9		в возрасте 90 суток на прочность 10		
		11 балочек	12 кубиков	11 балочек	12 кубиков	11 балочек	12 кубиков	11 балочек	12 кубиков	балочек	кубиков	
13 При проектировании состава бетона до начала бетонных работ от каждого состава бетонной смеси	Лабораторный 14	12	12	3	3	3	3	3	3	3	3	Для контроля за правильностью подбора состава бетона и за качеством материалов 15
При укладке бетонной смеси от каждых 200 $м^3$ укладываемого в покрытие бетона 16	"	9	9	3	3	3	3	—	—	3	3	Для контроля за качеством укладываемого бетона 17

Note. To control the concrete quality when the airport pavement is accepted for use one additional series of control specimens, which is stored for presenting ot the accepting commission, is prepared per each 5 series of control specimens (per each 1000 $meters^3$ of concrete mix).

1) When and from what concrete mix volume are control specimens taken; 2) method of storing the control specimens; 3) number of control specimens; 4) number of control specimens subjected to tests; 5) purpose of tests; 6) 7-day strength; 7) after 28 days; 8) for strength; 9) for frost resistance; 10) for 90 days strength; 11) of beams; 12) of cubes; 13) in designing the concrete composition starting with the start of concrete placing operations from each concrete mix composition; 14) laboratory; 15) for controlling the propre selection of the concrete composition and of the quality of materials; 16) in placing the concrete mix from each 200 $meters^3$ of concrete placed into the pavement; 17) for controlling the quality of the placed concrete.

ling cracks, if existing in individual slabs, should be treated by 2-3 applications of bitumen cutback.

The mechanical method for testing and controlling the quality of concrete which was in use up to the present time is very labor consuming and results in large concrete consumption. Lately special instruments using electrical signals and electronics have come into use for

determining the concrete strength and controlling its quality. This method makes it possible to save concrete, accelerate the process of control of the quality of work and to obtain more accurate results at the location in the finished pavement.

60. SAFETY PRECAUTIONS IN CONSTRUCTING CONCRETE PAVEMENTS

In placing the concrete mix all the workers must observe the movement of the concrete placing machines. The place at which the concrete placing machines work should be fenced off by warning signs and danger signals.

All electric tools, feed lines, breakers and knife switches should be in proper working order.

Wires bringing electric current to vibrators should be placed in rubber hoses and the housings of the vibrators should be grounded during operation.

All workers working with vibrators should wear ribber shoes and gloves.

All knife switches should be placed in boxes and closed.

Work with ethylene varnish, bitumen and tar emulsion, with bitumen cutback and mastic in sealing of joints must be performed in protective clothing and gloves.

Standing beneath the crane boom when dismantling or placing paving forms is forbidden.

Walking under the raised bucket of the D-181V spreader and entering the working areas of all machines in operation is forbidden.

If vibrators break down their working elements should be repaired after the concrete mix is placed.

In working on the moving bridge for sawing of joints it is forbidden to switch on vibrators of vibrating knives which either hang or are supported on the rigid pavement.

Gear, chain and belt-and-sheave transmissions on machines must be covered by jackets.

Removing of screens and shields installed on machines is forbidden.

The operators may not leave the machines with the engines working.

Lightning of all concrete placing machines and the entire work section during the night must be ensured.

After termination of work all working elements of the concrete placing machines should be cleaned an placed in the road position.

In placing of concrete mix containing salts with higher electrical conductivity particular care must be taken that the cables feeding power to the mechanisms be properly insulated and undamaged.

Workers charged with placing the concrete mix under subzero temperatures should be provided with warm working clothing and trained in safety rules for working with electrical tools in the winter time.

When performing work in the winter time safety rules and fire prevention measures must be strictly observed.

The distance between the concrete placing and concrete finishing machines working together should not be less than 10 meters. The servicing personnel is forbidden to stop the machines or to stand between them.

Placing of reinforcing cages near current carrying wires is prohibited.

When not working all the machines of equipment of the set of concrete placing machines should be in a position which makes impossible starting them up by outsiders, for which purpose the starting devices should be switched off and locked up.

61. ORGANIZING THE WORK

Organization of operations for the construction of concrete and

reinforced concrete airport pavements differs substantially from organizing the construction of similar road pavements. These pavements are constructed by pouring of parallel concrete strips, which by adjoining one another form runway, taxiway and or apron pavements.

Construction of the concrete pavement in airport construction is the main flow to which many other auxiliary flows are subordinated.

The concrete pouring scheme, on which the productivity of the concrete placing machines set and the quality of the finished pavement depend to alrge extent, serves as the basis of organizing the work in constructing concrete pavements.

Two main concrete pouring schemes - the longitudinal and longitudinal-section (Fig. 105) are used in constructing concrete pavements by the set of concrete placing machines.

In the longitudinal pouring scheme, which is considered more rational, the concrete is placed over sections of considerable length reaching the entire length of runways or group aprons. In this case the number of moves made by the set of machines from one row to another is decreased, which results in decreasing work interruptions and increasing the productivity of all the brigades in the section.

Concrete may be poured by the longitudinal system with developing the work from the middle to the edges, from one edge to another or from the edges to the middle.

The longitudinal concrete pouring scheme improves conditions for trucking in the concrete over previously placed slab rows, and also the operational readiness of the pavement (if necessary) for airport traffic.

The longitudinal concrete pouring scheme is used with a subpavement trench and foundation constructed over the entire length of the pavement under construction.

The longitudinal-section concrete pouring scheme is used when the construction of the trench entails a large volume of concentrated earth moving operations with respect to filling of filling of fills and quarrying of cuts with transverse displacement of soil. However, if at all possible, it is necessary in this case to make the length of the sections as long as possible, but not less than that minimally pssible, which will to a large extent promote decreasing unproductive downtime of the set of machines. The minimal permissible length of a section will be such for which the concrete strength in previously placed slabs can increase to an indicator allowing the passage of concrete placing machines over these slabs.

The minimally allowable section length is determined by the formula

$$L_{min} = \frac{Qc}{aK},$$

where L_{min} is the minimally allowable section length, meters; Q is the daily productivity of the concrete placing machines, meters^2/day; c is the time required, in days, for the concrete strength to increase to indicators ensuring the passage of machines (c is taken from Table 33); a is the width of one row of slabs, meters and K is the number of leading rows of slabs.

TABLE 33

Положительная температура воздуха, град. 1	2 Марка бетона (по изгибу)				
	35	40	45	50	55
	3 Среднее время, после которого разрешается движение бетоноукладочных машин и автомобилей по уложенному покрытию, сутки				
1	11/10	7/6	6/5	5/5	4/3
10	10/7	6/5	5/5	5/4	4/3
15	7/5	5/4	4/3	4/3	3/2
20	6/4	4/3	3/2	3/2	3/2
25	5/3	3/2	3/2	3/2	3/2
30	4/3	3/2	3/2	3/2	3/2

Note. The numerator contains the time during which the concrete placing machines are

in motion and the denominator gives the same for the truck.

1) Above zero air temperature, degrees; 2) concrete brand (in bending); 3) average time after which traffic or concrete placing machines and trucks over the placed pavement is permitted, days.

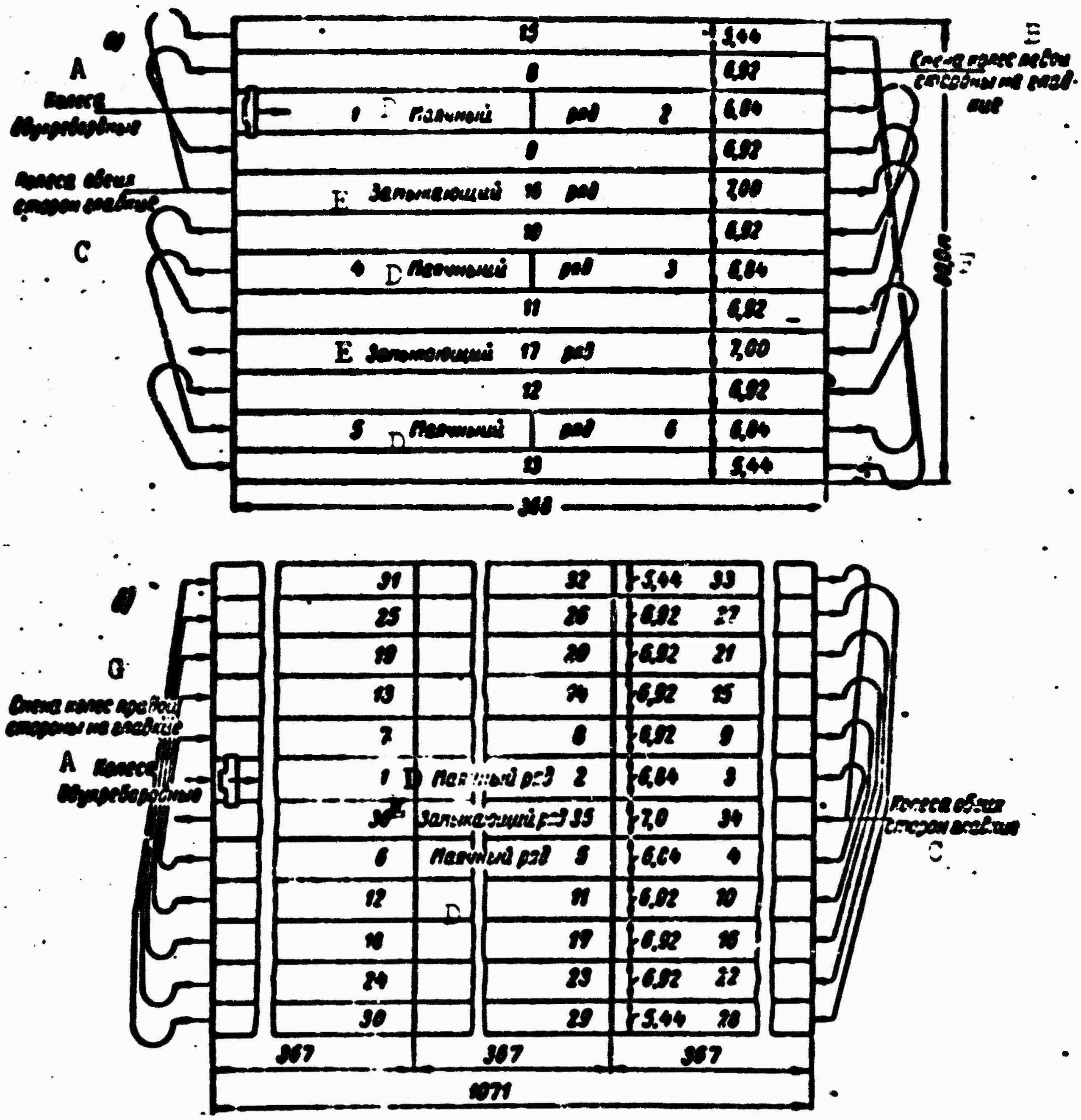
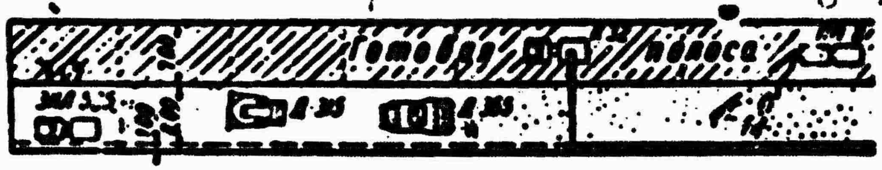
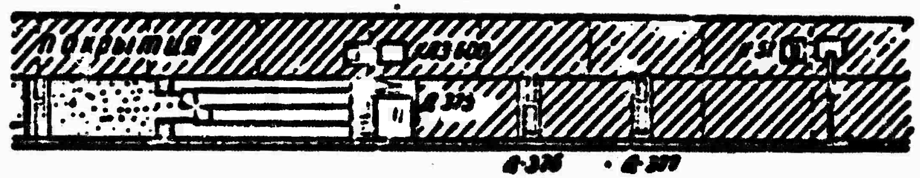


Fig. 105. Longitudinal-section scheme of concrete pouring. a) short section; b) long section; A) twin-flange wheels; B) replacing the left side wheels by smooth wheels; C) wheels on both sides are smooth; D) leading row; E) closing row; F) meters; G) replacing the right side wheels by smooth wheels.

The leading rows (see Fig. 105) are placed first and are used as

<table>
<tr><td>№ захваток 1</td><td>I</td><td>II</td><td colspan="4">III</td><td>IV</td></tr>
<tr><td>Состав работ на захватке 2</td><td>3 Окончательная планировка корыта.

Устройство песчаного подстилающего слоя: завозка песка, его распределение и предварительное уплотнение 3а</td><td>Установка рельс-форм, по данным инструментальной разбивки 4</td><td colspan="4">5 Окончательное профилирование, увлажнение и уплотнение песчаного слоя, раскладка бумаги, установка арматуры и прокладок температурных швов, распределение бетона, уплотнение его и отделка поверхности покрытия, нарезка температурных швов с заливкой их битумной мастикой, нанесение на покрытие битумной эмульсии или засыпка покрытия песком</td><td>6 Снятие рельс-форм и засыпка кромок бетонного покрытия песком</td></tr>
<tr><td></td><td colspan="2">7  8</td><td colspan="5">9  11 11</td></tr>
<tr><td>Средства механизации 10</td><td>Универсальный бульдозер Д-315—1 12

Каток на пневматических шинах Д-219 с тракторсм ДТ-54 или самоходный пневмокаток Д-365—1 19

Автомобили-самосвалы ЗИЛ-585 (по расчету) 25</td><td>Автокран К-32—1 13

Трактор МТЗ-2 с прицепом—1 20
Рабочие на укладке и закреплении рельс-форм—6 человек 26

Рабочие на уплотнении песка под рельс-формами электрошпалоподбойщиками ЭШП-3—2 человека 30

Электростанция ЖЭС-4,5 33</td><td>14 Профилировщик Д-345—1
21 Подвоочная машина ПМ-8—1
27 Подсобные рабочие, обслуживающие машину Д-345—2 человека
31 Рабочие на раскладке бумаги, установке арматуры, прокладок швов, отгибке штырей продольного шва и смазке рельс-форм—4 человека</td><td>15 Распределитель бетона Д-375—1
Бетоноотделочная машина Д-376—1
Автомобили-самосвалы КАЗ-6,0 22

Подсобные рабочие на зачистке кузовов автомобилей-самосвалов—2 человека 32</td><td>Нарезчик и заливщик швов Д-377—1 16
Подсобные рабочие на отделке швов и кромок покрытия—6 человек 23</td><td>Машина для розлива эмульсии и засыпки бетона тонким слоем песка—1 17

Подсобные рабочие—2 человека 29</td><td>Автокран К-32—1 13

Рабочие на снятии рельс-форм и засыпке покрытия песком—2 человека 24

Примечание. В состав отряда, кроме перечисленных выше рабочих, входят электрик и слесарь</td></tr>
</table>

Note. In addition to the enumerated workers the team also contains an electrician and mechanic.

1) Section numbers; 2) composition of work at the section; 3) final grading of the trench; 3a) constructing the sand base layer, trucking in the sand, spreading it and roughly compacting it; 4) placing of paving forms according to data of instrument setting out; 5) final grading, sprinkling and compacting of the sand layer, spreading of paper, placing reinforcements and temperature joint spacers; spreading the concrete, compacting it and finishing the pavement surface; sawing of temperature joints and sealing them by bitumen mastic, applying bitumen emulsion to the pavement or covering it with sand; 6) removing the paving forms and filling the edges of the concrete pavement by sand; 7) finished pavement strip; 8) PM-8; 9) KAZ-600; 10) ZIL-585; 11)D; 12) one D-315 general purpose bulldozer; 13) one K-32 truck crane; 14) one D-345 subgrader; 15) one D-375 concrete spreader; 16) one D-377 machine for sawing and sealing of joints; 17) one machine for applying emulsion and covering the concrete by a thin sand layer; 18) mechanization facilities; 19) one D-219 pneumatic tired roller with DT-54 tractor or self-propelled D-365 pneumatic tired roller; 20) one MTZ-2 tractor with trailer; 21) one PM-8 sprinkling machine; 22) one D-376 concrete finisher; 23) 6 auxiliary workers for finishing joints and pavement edges; 24) 2 workers for removing paving forms and covering the pavement with sand; 25) ZIL-585 dump trucks (amount obtained by calculation); 26) 6 workers for placing and fastening of paving forms; 27) 2 auxiliary workers for servicing the D-345 machine; 28) KAZ-600 dump trucks; 29) 2 auxiliary workers; 30) 2 workers for compacting the sand under paving forms by EShP-3 electrical swaggers; 31) 4 workers for spreading of paper, placing of reinforcements, joint spacers, bending of longitudinal jiont dowels and lubricating the paving forms; 32) 2 auxiliary workers for cleaning dump truck bodies; 33) ZhES 45 portable electric generator.

guiding strips.

The most efficient concrete pouring scheme is with one leading strip and proceeding from the middle to the edges of the runway. The concrete is placed by the set of concrete placing machines by an integrated brigade. The brigade's composition depends on the pavement thickness, the slab dimensions and on the pavement type and varies, for mechanized concrete placing, between 36 and 43 workers. The organization of the flow in comstructing a concrete pavement by a set of concrete placing machines is shown in Fig. 106. The productivity of the integrated brigade is up to 250 linear meters of pavement per shift.

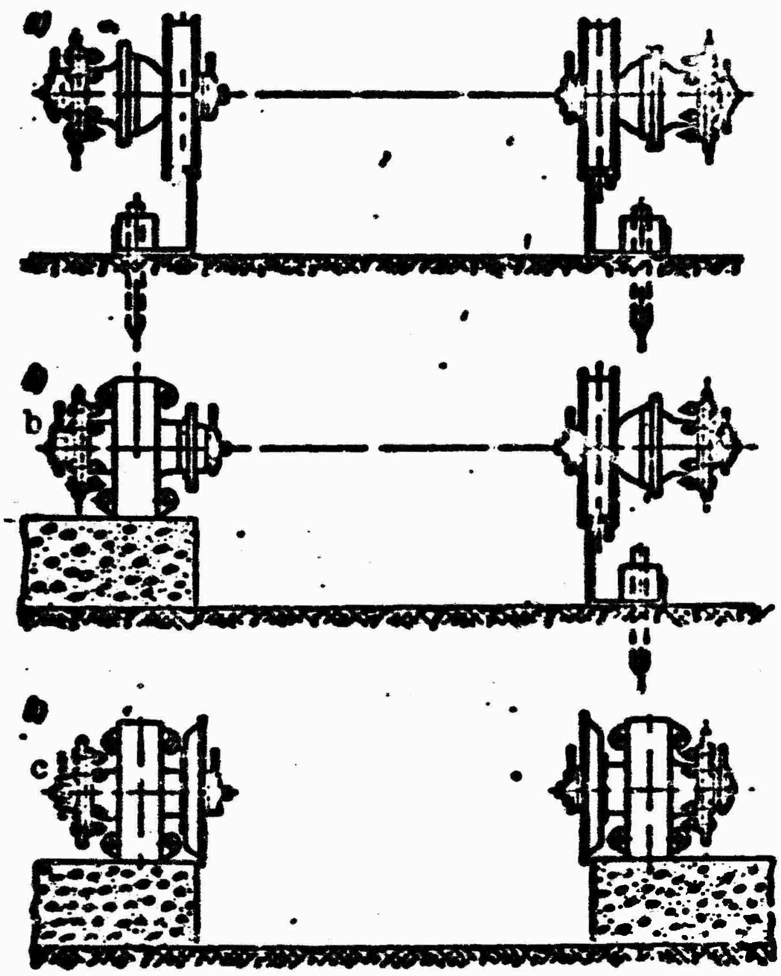


Fig. 107. Paving forms and the movement of wheels of machines for constructing cement concrete pavements. a) Motion over paving forms; b) motion over finished slab; c) motion over finished slabs.

Concrete is poured into leading, intermediate and closing strips with the wheels of concrete placing machines in different combinations:

in pouring concrete into leading strips the wheels from both sides move over the paving forms (Fig. 107a);

in pouring concrete into intermediate and edge strips the wheels at one side move over the paving forms, while at the other side they move over hardened concrete of the previously poured leading or intermediate strip (Fig. 107b);

in pouring concrete into closing strips the wheels on both sides move over hardened concrete of two neighboring intermediate strips (Fig. 107c).

As was shown by experience, it is difficult to obtain rectalinear motion when wheels move over the hardened pavement, which has a negative effect on the quality of compacting the concrete mix.

The smallest possible number of leading strips should be constructed in the longitudinal and longitudinal-section concrete pouring schemes.

Chapter 8

CONSTRUCTING MONOLITHIC PRESTRESSED PAVEMENTS

62. GENERAL CHARACTERISTIC AND KINDS OF PRESTRESSED REINFORCEMENT

In nonreinforced concrete of airport pavements cracks appear with time under the action of loads and atmospheric factors. Up to recently these were eliminated by constructing pavements from small slabs, using ordinary slab reinforcement and rigid foundations. However, all these measures result in large consumption of concrete and reinforcement steel and, due to large joint lengths, lower the operational indicators of concrete pavements.

In the last few years the quality of reinforced concrete airport pavements in our country and abroad is being improved by prestressing the reinforced concrete pavements.

Prestressed reinforced concrete pavements, depending on the amount of compression, can without cracking up sustain tensile stresses exceeding by several fold those that can be taken by ordinary not prestressed reinforced concrete pavements of the same thickness. Even after large temporary overloads the carrying capacity of prestressed pavements is restored and the cracks which do appear close up.

All these positive qualities make it possible to construct reinforced concrete pavements from large slabs, to decrease the number of joints and the pavement thickness and to decrease the metal consumption by a factor of 2-3 and of concrete by up to 30%.

The adaption of prestressed reinforced concrete requires the solution of two basic problems:

1. In order to decrease settling and creep of the concrete it is necessary to use dense stiff mixes with a water-cement ratio of 0.3-0.45 and with a bending strength not lower than 50 kg/cm^2, since ordinary porous concretes when subjected to stresses give large plastic contractions over the pavement length.

For this reason, when using porous concrete, the prestressed rods are relieved of their stresses and the precompression of the pavements can disappear entirely.

Stiff concrete mixes should not be produced at ordinary concrete plants with intermittent action concrete mixers with free intermixing, but in continuous action mixers with forced reverse flow intermixing.

2. High strength wire with diameters from 2.5 to 8 mm with an ultimate strength of over 10,000 kg/cm^2 should be used as the reinforcements subject to prestressing (Table 34).

TABLE 34

Вид арматуры a	b Диаметр проволоки, мм						
	2,5	3	4	5	6	7	8
	Нормативные сопротивления арматуры, кг/см^2 c						
Проволока стальная высокопрочная холоднотянутая: d							
круглая углеродистая по ГОСТ 7348—55 . . e	20 000	19 000	18 000	17 000	16 000	15 000	14 000
периодического профиля углеродистая по ГОСТ 8480—57 . f .	18 000	17 000	16 000	15 000	14 000	13 000	12 000

a) Kind of reinforcements; b) wire diameter, mm; c) nominal resistance of the reinforcements, kg/cm^2; d) high-strength, cold-drawn steel wire:; e) round carbon according to GOST 7348-55; f) periodic profile carbon according to GOST 8480-57.

This high strength steel wire has an elastic effect, stretches in tension to lengths exceeding several fold those of the subsequent plastic shrinkage of the concrete upon compression and setting. The

higher the strength of reinforcements used, the less concrete and steel is needed for compensating the prestressing losses.

The use of high-strength stiff concrete mixes which settle and creep only slightly, and the use of high strength steel with high elongation qualities are thus the basic necessary conditions for efficient use of prestressed reinforced airport reinforced concrete.

A distinction is made between stressing the reinforcements before and after concrete pouring on the basis of the time at which the force is applied.

In stressing before pouring the reinforcements, in the shape of steel wire, are stressed up to 70% of the ultimate strength and then the concrete is poured. When the concrete hardens and acquires the design strength, the reinforcements at the ends and in the joints are cut and the prestressing is transferred to the concrete. In this case the loss of tension due to friction between the wire and the concrete is eliminated, complete coupling of the wire over the entire length without mutual slip is ensured and favorable conditions are created for protecting the reinforcements from corrosion.

In stressing after pouring the concrete the reinforcements, in the form of bundles, slide in the longitudinal direction over channels inside the concrete body without coupling with it. After stressing the reinforcements are anchored at the ends, and the prestressing is transferred to the pavements. To maintain the design stress after the concrete sets the stretching can be repeated. After restretching, the reinforcements and the concrete can be coupled by filling the channel with cement grout under pressure.

In creating of stresses after the pavement concrete is poured a large amount of force is lost due to friction between the reinforcements and the concrete and work for corrosion protection is more com-

plicated. In addition, the engineering process for pavement construction with stressing after concrete pouring does not lend itself to integrated mechanization and many operations are performed manually. For this reason at the present stage of design solutions pavements with stressing of reinforcement bundles after concrete pouring are not widely used and will not be discussed in detail.

63. CONSTRUCTING PAVEMENTS WITH STRESSING THE LONGITUDINAL REINFORCEMENTS BEFORE CONCRETE POURING

Prestressed reinforcement of monolithic reinforced concrete pavements in the longitudinal direction is performed by using high-strength wire placed by the mechanized method (Fig. 108).

For concrete pouring purposes the pavement is broken up into sections 500-1000 meters long with rows, as a rule, 7 meters wide. The ends of the sections are conventionally designated as follows: section end A and section end B (Fig. 109). The anchor slabs are constructed before and the longitudinal wire reinforcements are fastened to them by special standard fasteners for the entire duration of stressing and concrete hardening. The anchor slabs are subsequently used as finished sections of the pavement.

The stressing of the longitudinal reinforcements can be checked by the design force or by the design elongation in each bar.

The flow for constructing pavements with prestressing by longitudinal working reinforcements consists of the following operations:

final grading and rolling of the trench bottom;

constructing anchor and base slabs;

constructing the artificial foundation;

preparing the wires for placing;

spreading the longitudinal wires;

stressing the wires;

pouring concrete for the pavement in the section by rows with placing of transverse nonstressed reinforcements;

sawing of longitudinal joints;

curing the concrete;

cutting the wire reinforcements at the ends and in transverse joints;

constructing the joints.

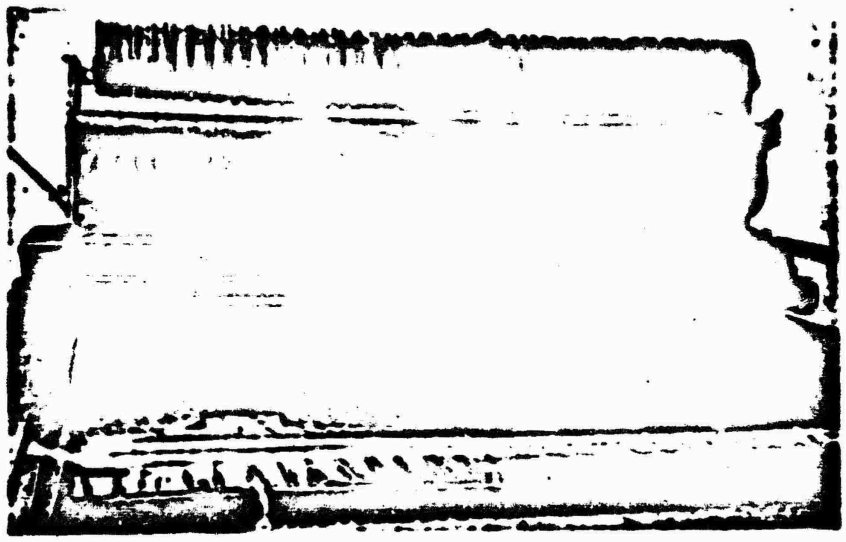


Fig. 108. General view of the AM-63 reinforcement placing machine during spreading of the wires.

All the enumerated processes are performed by the rapid flow method by a special set of machines and equipment which include machines for rewinding the wires, a set of installation equipment for fastening the longitudinal wire reinforcements, stretching facilities, placing machine, moving chaser for keeping the longitudinal reinforcements in the design position during concrete pouring, spring dynamometers for checking the stress in the wire reinforcements (see Fig. 109), wtc.

Constructing the anchor and base slabs. Reinforced concrete anchor slabs are constructed ahead of time. The cross sectional dimensions of anchor slabs (Fig. 110) are specified by strength calculations and their length is the same as the width of the runway, taxiway

or apron pavement being constructed. Channels for anchor pullrods are constructed by placing wooden through boxes with a hole of 15 x 15 cm. The elevations of the anchor slab surfaces should conform to the desing elevations of the pavement.

Another slabs are a part of the reinforced concrete pavement with ordinary, unstressed reinforcement. On heavy heaving grounds the anchor slabs are placed on draining foundations with the trench provided with water drainage. Base slabs are constructed at the points where transverse joints are situated in order to reinforce them (Fig. 111). The elevations of base slabs should conform to the elevations of the pavement foundation. The base slabs are poured in a continuous manner, without constructing joints.

When pouring concrete at the middle of the base slab, wooden stoppers 16 mm in diameter wrapped in roofing tar paper are placed each 1.5 meters of its width, in order to produce through holes used subsequently for fastening a wooden spacer serving as a mold for joints. If the thickness of the reinforced concrete pavement is less than the standard height of the paving forms, then in pouring of base slabs provisions should be made for depressions equal to the difference between the height of the paving forms and the pavement thickness, whose width is by 5 cm wider than the base of the paving forms, and the position of these depressions should conform to the assumed concrete pouring scheme.

The monolithic versions of anchor and base slabs elaborated in our country do not lend themselves to integrated mechanization in their construction, i.e., practically all the operations are performed manually: placing the reinforcements, concrete pouring, constructing channels in the anchor slabs and holes in the base slabs, and the slabs must be aged for a long time, which does not satisfy requirements

of flow production of reinforced concrete pavements. In the present day stage of the development of the construction industry it is possible and expedient to construct anchor and base slabs from prefabricated elements which would be made monolithic by butt joining by welding and expansion cement.

Preparing and placing the longitudinal wire reinforcements. The wire reinforcements are prepared for spreading at the preparatory works area and this operation consists of cleaning and rewinding the reinforcements from the plant bundle onto the reels of the reinforcement placing machine.

The reinforcements yard has a shed for storing the reinforcements and a machine for winding it (Fig. 112). The required length of wire is measured during rewinding by a special counting mechanism. The measured wire should be slightly more than twice the length of the poured section. The wire is cleaned of rust and lubricants by pulling it through dry washed sand when winding it onto the reels. The sand is replaced after winding of one set of reels.

The placing of the longitudinal reinforcements should be preceded by construction of the sand foundation, placing of paving forms, covering the foundation with waterresistant paper and by placement on concrete supports of lower transverse assemblying bars for maintaining the longitudinal working wire reinforcements at the design height.

The longitudinal reinforcements are placed before pouring by a self-propelled reinforcements placing machine by passing the section in both directions. The lower layer is placed when moving in one direction and the second is laid on the return trip. The machine moves over paving forms or over the edges of a poured pavement. In order to prevent inertia unwinding and to create the necessary stress in each wire (3-10 kg), the reels are provided with friction brakes. The wires

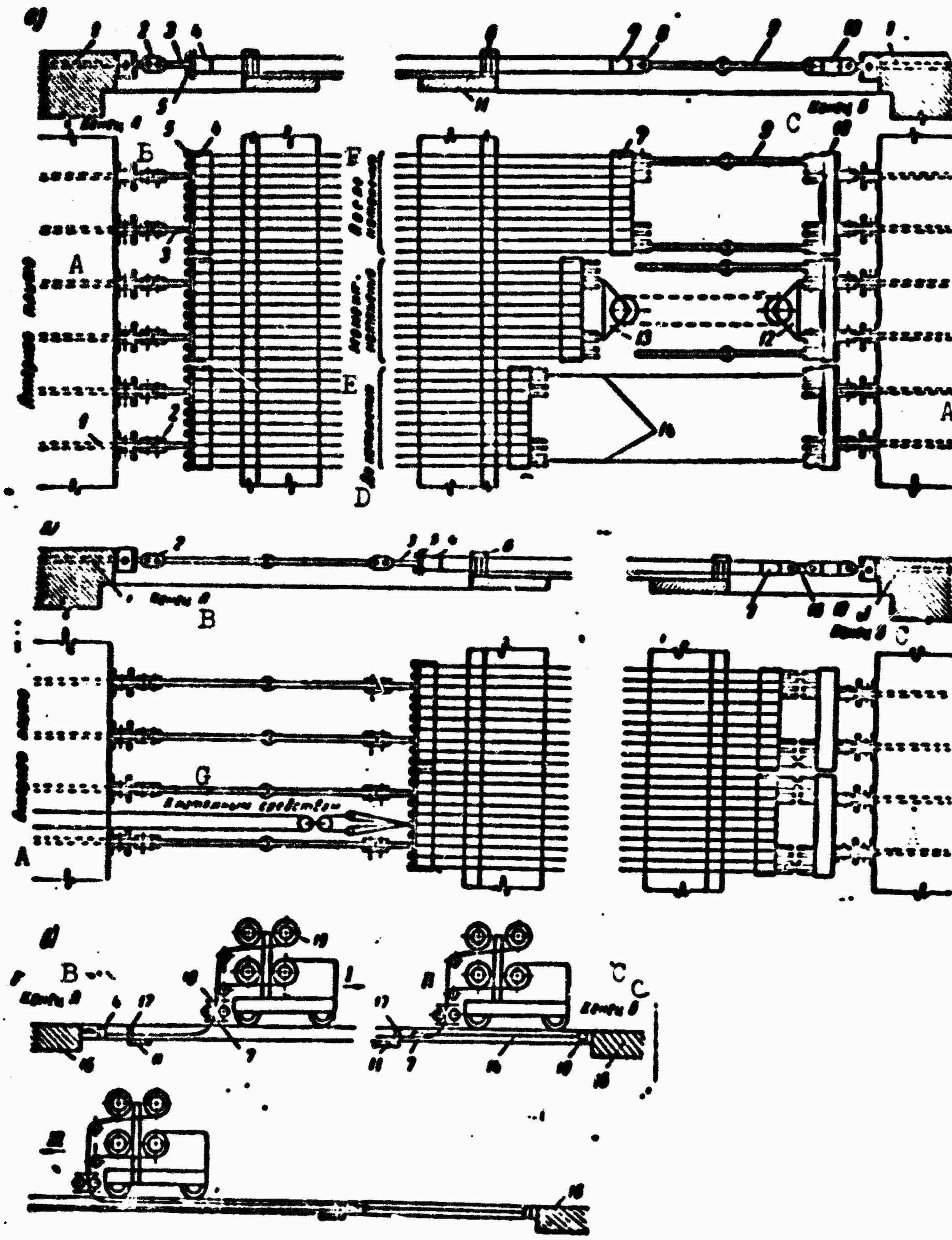

A
Б
C
D
E
F
G
B

Fig. 109. Arrangement of equipment for stretching the wires. a) By the controlled elongation method; b) by the controlled force method; c) scheme of placing reinforcement wires by the AM-63 machine when stretching is performed by the controlled elongation method. I) First pass (placing of lower layer wires from end A to end B); II) placing of slab beams on the wires; III) second pass (placing of upper layer wires); 1) anchor pullrod; 2) connecting link; 3) pullrod (short); 4) permanent anchor beam; 5) tapered anchor sleeve; 6) end molds; 7) beam slab; 8) dowel; 9) working pullrod; 10) thrust beam; 11) base slab; 12) fixed compound pulley frame; 13) moving compound pulley frame; 14) installation pullrods; 15) loop; 16) anchor slab; 17) wooden mold section; 18) upper distributing molding; 19) reel; A) anchor plate; B) end A; C) end B; D) before stretching; E) during stretching; F) after stretching; G) to stretching equipment.

from all reels are placed from the bottom of the machine through guiding rolls. The maximal number of wires placed in one pass simultaneously should not exceed 100 for wire diameters of 4 mm and 308 for wire diameters of 3 mm.

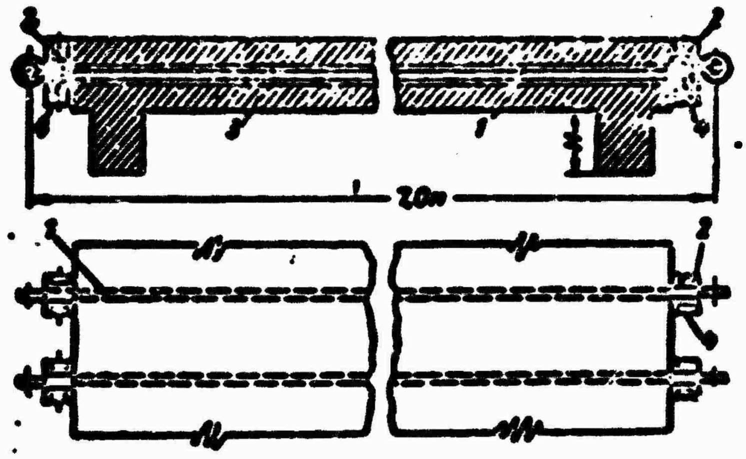


Fig. 110. Design of a 7 meter wide anchor slab. 1) Anchor pullrod; 2) support shoe; 3) anchor slab; 4) dowel; A) meters.

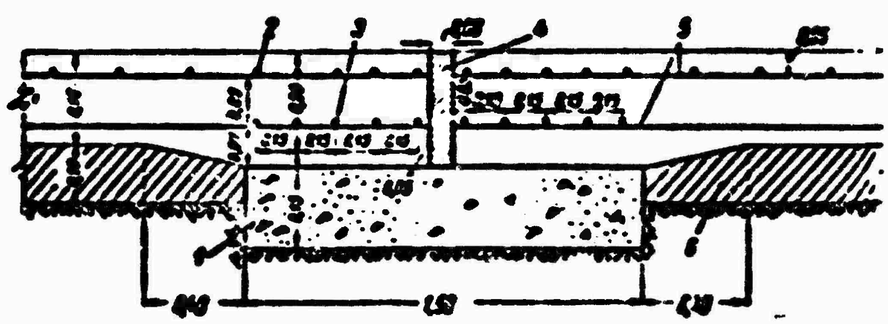


Fig. 111. Design of a transverse joint. 1) Base slab; 2) and 3) transverse upper and lower reinforcements; 4) filler (asphaltic concrete or mastic); 5) high-strength longitudinal wire reinforcements; 6) foundation.

Prior to placing the wire the machine is positioned at end A and is provided with reels of wire. Fixed tapered anchor beams are placed at end A and fastened to the anchor slab, and thrust beams are placed and fastened to the anchor plate at end B (see Fig. 109). The lower molding boards are placed on the base slabs. The wire ends are, in pairs, passed through the distributing molds and fastened to the fixed anchor beams in the lower row by tapers and sleeves.

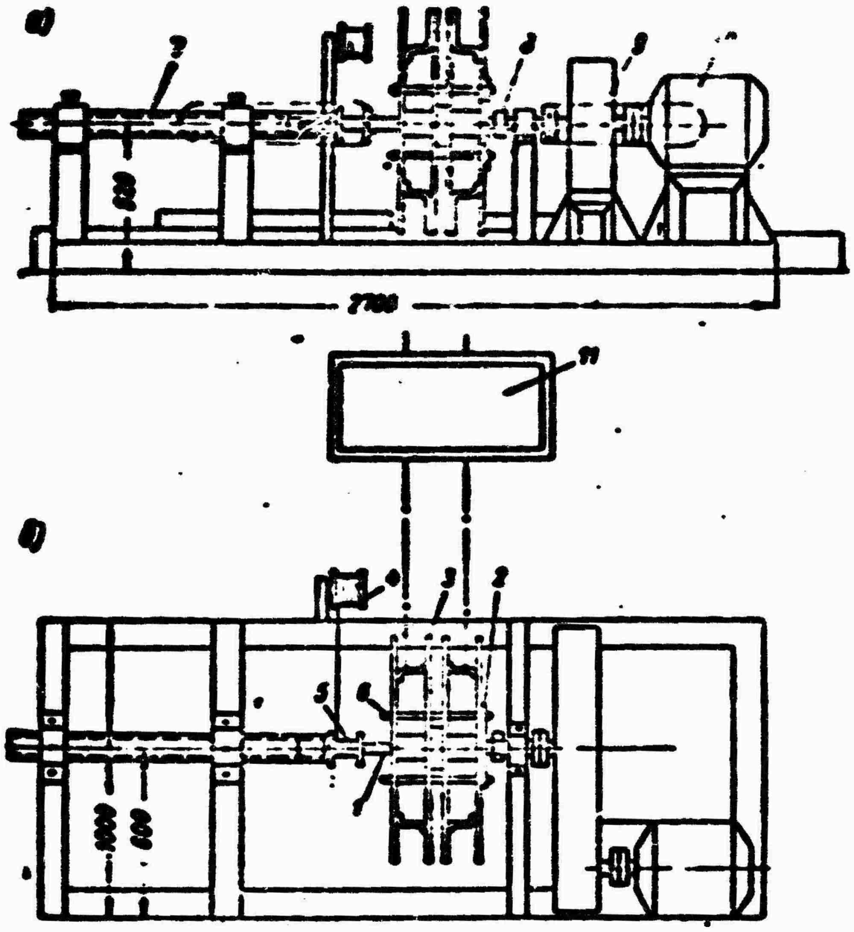


Fig. 112. Machine for winding of wire onto the reels. 1) Shaft; 2) rotor; 3) reel; 4) bracket-supported drum; 5) shaft-supported drum; 6) bolt; 7) removable pipe; 8) hings; 9) reducing gear; 10) electric motor; 11) sand.

Before the machine starts to move the wire is distributed into slits of the extreme wooden molding and is kept in this position by placing the middle mold boards, fastened with nails.

After all the wires are fastened the machine moves over the paving forms to end B and places the lower layer of the working reinforcing wire. When the machine places the next distributing mold it stops, the wire is placed in the slits of the lower board and is kept there permanently by placing and nailing of the middle boards of the molding.

When the machine reaches end B it stops past the extreme mold board and block beams fastened to the installation pullrods are placed on the wires. When the reinforcement placing machine moves in the reverse direction the upper layer of wires is placed in the same manner. The reinforcements are fastened to the block beams at end B by winding

wire over them. The upper layer of wires is held in the slits of each mold by placing the upper board.

The wires of the upper layer are fastened at end A in permanent anchor beams by tapered sleeves and are cut off from the reels. The reinforcement placing machine moves away from the section. In order to ensure stability of the guiding molds during the stretching of wires they are fastened to base slabs by dowels and wire splices.

Stretching the longitudinal wire reinforcements. Stretching by the controlled stress method is used for wire diameters lower than 4 mm with anchoring of one piece in one sleeve. The reinforcements are tensioned by moving the movable block beams through a specified design distance whereupon the installation pullrods are replaced by working pullrods to which the block beams must be moved. The stretching pullrods are produced at the site.

The distance through which the block beams are moved is calculated by the given design stress in the wire and by the section length:

$$l_u = L\frac{\sigma}{E} + l_p$$

where l_u is the required moving distance, cm; L is the section length, cm; σ is the wire stress specified by design; E is the modulus of elasticity for steel, kg/cm^2 and l_p is the additional technological elongation, cm.

The length of the installation pullrods is determined as the sum of the length of the working pullrod (250 cm) and the required displacement distance. Before tensioning the longitudinal reinforcements by the controlled elongation method the slacks are taken up in each wire by the following forces: up to 10 kg for wire with diameters of 3 mm and up to 17 kg for wire 4 mm in diameter. The wires are stretched manually for taking up the slack by using a dynamometer.

The main tensioning of the wire reinforcements is performed in

the folloqing sequence. The moving and fixed compound pully frames are fastened to the free links of the block beam and the thrust beam. The installation pullrods are removed and are replaced by two working pullrods fastened to the thrust frame. The block beam is moved in the direction of the thrust beam by a winch, jack or by a powerful tractor through a compound pulley. The wires are tensioned in several passes with moderate stops of 2-3 minutes in order to allow distribution of internal stresses in the wire. All the signal during tensionsing are made by convential signs or by telephone by the operational chief. After the design tension has been obtained, the working pullrods are fastened and the compound pulley is disconnected. The tension in each wire is checked by a dynamometer. Deviations from the design tension must be kept within the limits of ± 10%. The wire is tensioned by controlled tension method in groups of four wires by an electric winch with a dynamometer and a system of pulleys (Fig. 113). The wires are stretched with two stops of 2 minutes [each]: the first stop is made after reaching 70% of the design tension and the second is made after reaching 90% of the design tension, after tensioning the wires are fixed in anchor sleeves.

Pouring the pavement. After the longitudinal wire reinforcements are tensioned the pavement is poured by a set of D-181V or D-375 concrete placing machines. The concrete pouring scheme is arranged with the smallest number of adjacent rows to be poured. When pouring by the D-181V machine the transverse reinforcing rods are placed on the upper tensioned wire from the concrete spreader and they are held in the design position by portable guiding molds which are removed after the machines passes (Fig. 114). The bars of the lower transverse working reinforcement are placed over the lower tensioned wire before the concrete is poured and are held in the design position by tying them to

the longitudinal wires by thin annealed wires. The lower reinforcements in this case are maintained at the design height by special installation bars placed every 3-4 meters on concrete supports. In the concrete spreading process the design position of all the reinforcements must be strictly controlled. It was discovered that the leading rollers of the D-181 concrete placer skid when moving with a portable guiding mold. For this reason the forward and rear axles of the machine must be con-

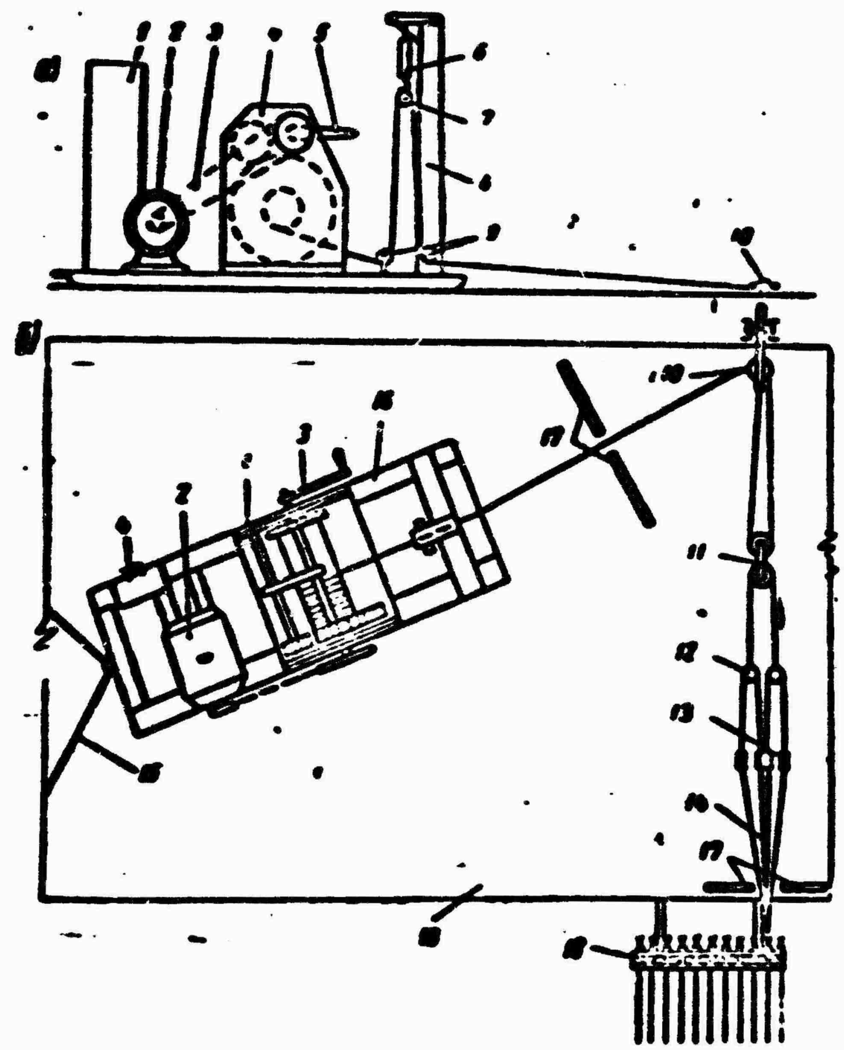


Fig. 113. Scheme for pretensioning of wires by a driven winch. a) Is the general view; b) is the tensioning arrangement. 1) Switch; 2) electric motor; 3) chain drive; 4) single drum winch; 5) removable winch handle; 6) dynamometer; 7) upper pulley; 8) support; 9) guiding pulleys; 10) rotating pulley; 11) frame with pulleys; 12) balancing pulleys; 13) holding devices; 14) wire being tensioned; 15) fastening cable; 16) frame; 17) fencing; 18) immovable anchor beam; 19) anchor slab.

nected by a chain transmission. If work is performed by the D-375 machine (Fig. 115), then the main reinforcement bars are placed on the

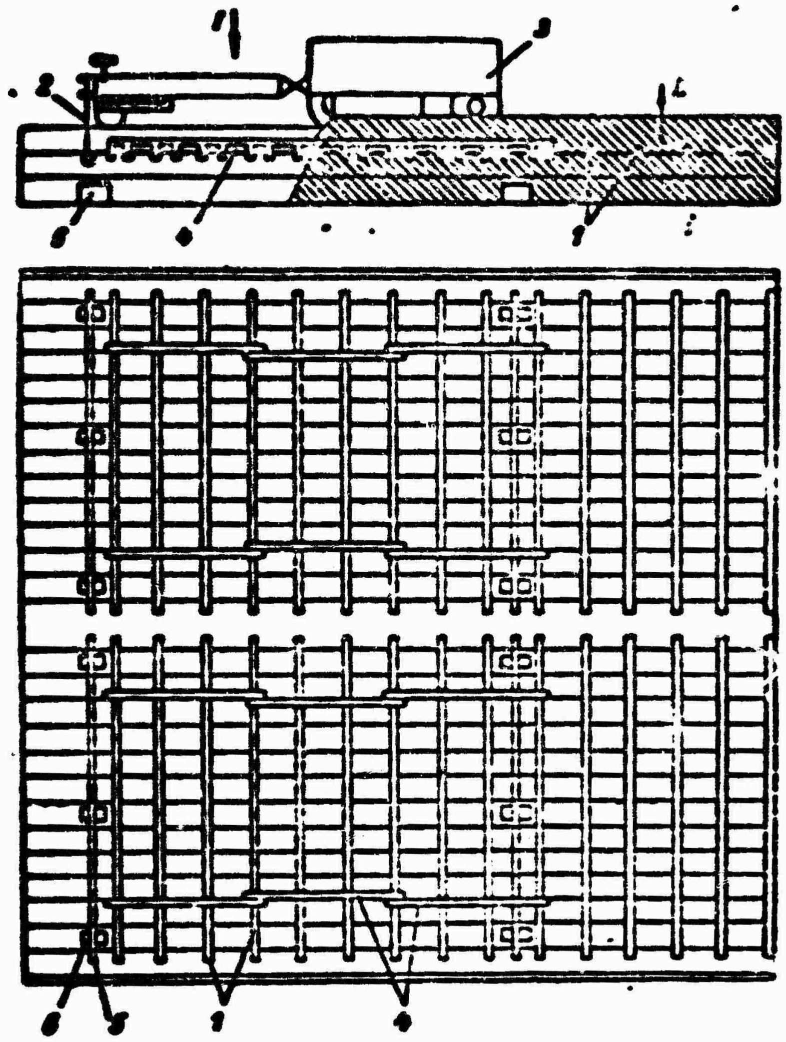


Fig. 114. Scheme of placing reinforcement bars and movable guiding molds in pouring a pavement by a machine such as D-181V. 1) Reinforcement bars on the top layer of the reinforcement wires; 2) rolling suspensions; 3) D-181V machine; 4) movable guiding mold; 5) reinforcement bar supporting the lower layer of reinforcement wires; 6) concrete support; I) placing of renforcement bars and movable guiding molds; II) removing the movable guiding molds.

wires ahead of the concrete placing machine and are held by movable guiding molds which are removed after the machine has passed. After the concrete is spread the D-182V (D-376) vibrational finishing machine begins its work. If the design provides for the construction of a longitudinal dummy joint, then the transverse reinforcement is constructed from short bars with 10 cm gaps in the middle of the concrete pouring row. In this case the longitudinal joint is sawed by the D-195V (D-377) joint sawing machine or, 8-20 hours after the concrete was poured, by the D-432 machine. The joints are sealed and the concrete is cured in

accordance with applicable engineering rules.

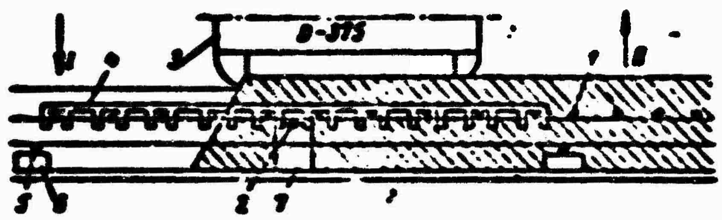


Fig. 115. Scheme of placing reinforcement bars and movable guiding molds when using the D-375 concrete placing machine. 1) Reinforcement bars on the top layer of the reinforcement wires; 2) reinforcement bar supporting the upper layer of wires; 3) concrete placer; 4) movable guiding mold; 5) reinforcement bar supporting the lower layer of wires; 6) and 7) concrete support; I) placing of reinforcement bars and movable guiding molds; II) removing the movable guiding molds.

64. CONSTRUCTING PAVEMENTS WITH POSTTENSIONING OF BUNDLE REINFORCEMENTS

In this type of pavement the prestress in the concrete slabs is created in one or both directions by using bundle reinforcements placed over the neutral layer of the slabs and tensioned after the concrete has achieved not less than 70% of its design strength. The reinforcement bundles (Fig. 116) are produced from smooth high-strength wire up to 5 mm in cross section. The number of wires in a bundle and their diameter are determined by design.

In order to prevent binding with the surrounding concrete the bundle reinforcements are encased in metal jackets or wrapped by several layer of parchment.

The ends of the bundles are held by anchor stays with tapered inserts, designed for the use of twin-action jacks.

The following processes make up the operations of constructing prestressed concrete pavements with bundle reinforcements:

constructing the trench;

constructing bearing slabs and intermediate support slabs;

constructing the foundation;

producing the reinforcement bundles;

placing of paving forms for pouring of the primary rows;

placing, fastening and preliminary stretching of the reinforcement bundles within the limits of one section;

placing concrete supports with dimensions of 5 x 6 x 20 cm at the points of intersection of the bundles;

placing of channel forms into the molds for letting through of transverse bundles after concrete pouring;

pouring concrete into the primary rows;

removing tubes for transverse channels and preliminary stretching of the longitudinal bundles;

pouring concrete into secondary rows;

pulling transverse bundles through the channels;

tensioning of longitudinal and transverse bundles by jacks;

injecting cement grout into the channels;

pouring concrete into all the engineering gaps between the sections with simultaneous closing of anchor installations of the longitudinal reinforcements;

pouring concrete for gutter pavements with simultaneous closing of anchor installations in the transverse reinforcements.

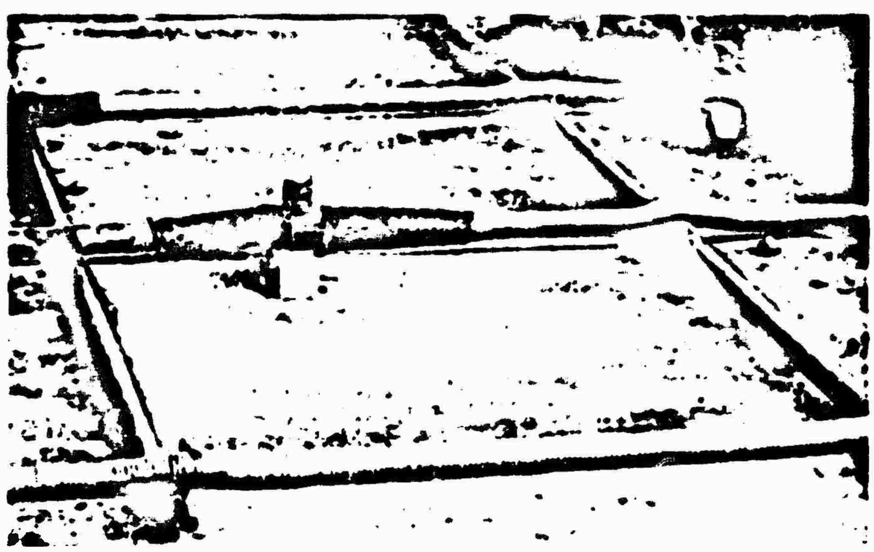


Fig. 116. Reinforcing bundles for longitudinal and transverse tensioning, prepared for concrete pouring.

It was shown by experiments performed under production conditions that extensive use should be made of monolithic prestressed wire reinforced concrete pavements, since they ensure the use of flow construction utilizing integrated mechanization of all the processes.

Prestressed pavements with bundle reinforcements do not lend themselves to integrated mechanization, and many operations are performed manually. These operations include: insulation of the reinforcement bundles; supplying and placing of bundles at the section, installation stretching at the section; installation stretching of the bundles; placing of tees for injecting cement grout into the bundle's channels, placing into the primary rows of devices for forming channels for the transverse bundles, pulling the transverse bundles into the channels and insulating them in the secondary rows, tensioning the bundles, injecting cement grout into the bundle channels, insulating the anchoring devices, pouring concrete into the design gaps, etc.

Favemtns with bundle reinforcements are not being extensively used at the present stage.

65. SAFETY MEASURES AND CONTROLLING THE WORK QUALITY

Safety Measures

All the equipment used for tensioning the reinforcements should be tested for strength at the work site before using.

Both ends of the section should be connected by communications for mutual information and timely warning of persons observing the state of the equipment when tensioning the reinforcements.

Before the tensioning facilities are started up, an agreed upon sound signal is given and a red flag is raised at the point where the tensioning equipment is located.

A fence of signs warning about the beginning the tensioning operations is placed over the entire length of the section each 50 meters

between the anchor slabs where the wires are stretched, to both sides of the row.

Boards 30-40 mm in cross section are placed before tensioning over the entire section each 10 meters on top of the wires to be stretched and each 2 meters at one plate adjoining the point at which the tensioning facilities are situated.

Standing on the stretched wire after the reinforcements have been tensioned in prohibited. Cross-over bridges with rails should be constructed for walking over the stretched wires.

The working pullrods may be fastened only after boards have been placed in a continuous layer between the beam pulley and the end guiding mold.

When spreading concrete on the stretched wires portable boards are placed ahead of the concrete placer each 5 meters for at least 50 meters, and are moved as the machine drives ahead.

A guard rail is constructed on the concrete placer from the side of wires not yet poured.

Controlling the Quality of Work Performance

Final grading of the trench, constructing the foundation, preparation, hauling and placing of concrete mix when constructing monolithic prestressed airport pavements are performed in the same manner as in constructing nonstressed reinforced concrete pavements.

Control specimens of the reinforcement wires for strength tests are taken in the amount of not less than 6 pieces per each shipment arriving at the construction site with 3 specimens taken from each shipment for bending tests.

Not less than 5% of wire bundles supplied are subjected to check measurements of the wire diameter. The allowable deviations from the standard may not exceed 0.1 mm.

The design tension in the wires is checked by a dynamometer by the value of the elongation obtained. The deviations of the actual value of tension in individual wires from design specifications may not exceed ± 10%.

The stresses may be transferred from the reinforcements to the concrete when the concrete reaches 0.7 of its design strength in the case of bundle reinforcements and when it reaches 0.9 of the design strength for wire reinforcements.

A special book is kept during the construction of monolithic pre-stressed reinforced concrete pavements, in which the results of all checks are recorded by persons responsible for the quality control of the construction.

Chapter 9

CONSTRUCTING PRECAST REINFORCED CONCRETE PAVEMENTS

66. GENERAL CHARACTERIZATION AND COMPOSITION OF OPERATIONS

The use of precast airport slabs ensures complete industrialization of the pavement construction, eliminates the seasonal character of operations and considerably increases the coefficient of utilization of machines and equipment.

Among the advantages that precast pavements hold over monolithic pavements we should also count the fact that they can be produced at plants of reinforced concrete products, using all the achievements of the modern construction industry.

Industrially prepared prestressed reinforced concrete slabs are used for precast pavements. The basic characteristics of typical slabs are given in Table 35.

The slabs are placed on a prepared artificial foundation which is designed upon consideration of the climatic and hydrogeologic conditions of the construction region.

Sand, sand and gravel mixes, slag, soil cement and also crushed stone and soil gravel treated with organic binders may be used as materials for artificial foundations.

In placing slabs directly on a soil foundation a leveling layer 4-6 cm thick is constructed from sand. If the foundation is made from soil cement or is treated by organic binding materials, then the leveling layer is made from dry sand cement mix.

Typical slabs, with the exception of PAG-IX slabs are joined to-

gether by welding at the joint elements. For this purpose each slab face has two brackets which are welded to the brackets of neighboring slabs. To form expansion joints the slabs are left unwelded each 15-20 meters. Joints between slabs are filled with PN-2 bitumen mastic. When placing slabs into a pavement, tight adherance of the lower slab surface to the foundation and evennes of the pavement surface must be ensured.

Under unfavorable hydrologic conditions, when the design provides for the construction of open gutters on the pavement, they can also be produced from precast slabs on the construction site yard in accordance with special drawings.

A shoulder up to 1.5 meter wider is constructed along the edges of runways, taxiways, aprons and terminals.

The work for constructing precast alab pavements (on a prepared trench) consists of the following engineering processes:

storing and transporting the slabs;

constructing the man-made foundation;

placing the slabs into a pavement;

constructing the joint connections.

The engineering arrangement for assembly of a pavement is given in Fig. 117.

67. STORING AND TRANSPORTING THE SLABS

The reinforced concrete slabs are usually supplied from the producing plant to the construction site warehouse by railroad or, less frequently, by trucks.

In order to ensure convenient and rapid unloading of slabs from railroad flatcars, the length of the unloading platform should be slightly greater than the length of the rolling stock being used.

Truck cranes such as the K-102 or K-123 are used for loading and

TABLE 35

1 Типы плит и схема армирования	2 Размеры, м	3 Толщина, см	4 Вес, т	5 Расход арматуры, кг: 6 предварительно напряженной	7 ненапряженной	8 общий
9 ПАГ-III. Продольная арматура предварительно напряженная из стали марки 30ХГ2С, 14 мм, поперечная — обычная, 5 мм	2.0×4.0	14.0	2.8	49.5 / 6.2	45.3 / 5.65	94.8 / 11.85
ПАГ-IV. Продольная арматура предварительно напряженная, 3 мм, поперечная — обычная, 5 мм . . 10 . . .	2.0×4.0	14.0	2.8	22.9 / 2.85	45.3 / 5.65	68.2 / 8.5
ПАГ-IX. Двухслойная предварительно напряженная арматура в двух направлениях, 3 мм . . . . . 11 . . .	3.2×6.0	14.0	6.7	95.0 / 4.95	7.5 / 0.4	102.5 / 5.35
ПАГ-XV-1. Продольная арматура предварительно напряженная, 3 мм, поперечная — обычная из холоднотянутой проволоки, 5 мм . 12 . . .	1.95×5.86	14.0	4.0	34.8 / 3.05	61.7 / 5.40	96.5 / 8.45
ПАГ-XIV. Продольная арматура предварительно напряженная стали марки 30ХГ2С, 14 мм . . . . . 13 . . .	2.0×6.0	14.0	4.2	65.34 / 6.45	61.9 / 5.15	127.2 / 10.6
ПАГ-XV. Продольная арматура предварительно напряженная, 3 мм, поперечная — обычная, 5 мм . 14 . . .	2.0×6.0	14.0	4.2	29.3 / 2.45	61.9 / 5.15	91.2 / 7.6

Note: The numerator gives the reinforcement used up per slab, while the denominator gives the same per 1 meter^2 of slab.

1) Slab types and reinforcing system; 2) dimensions, meters; 3) thickness; cm; 4) weight, tons; 5) reinforcements used, kg; 6) prestressed; 7) unstressed; 8) total; 9) PAG-III. Longitudinal prestressed reinforcements from 30KhG2S steel brand, 14 mm, transverse is ordinary, 5 mm; 10) PAG-IV. Longitudinal reinforcements are prestressed, 3 mm, transverse reinforcements are ordinary, 5 mm; 11) PAG-IX. Twin-layer prestressed reinforcements in two directions, 3 mm; 12) PAG-XV-1. Longitudinal reinforcements are presented, 3 mm, the transverse reinforcements are ordinary from cold drawn wire, 5 mm; 13) PAG-XIV. Longitudinal reinforcements are prestressed from 30KhG2S steel brand, 14 mm; 14) PAG-XV. Longitudinal reinforcements are prestressed, 3 mm, the transverse reinforcements are ordinary, 5 mm.

unloading work. The team servicing a crane consists of 5 workers (1 operator and 4 rigging men). The average productivity of cranes performing loading an unloading operations is 100-130 slabs per shift.

The slabs are unloaded along the railroad tracks in one or several rows. In the construction site warehouse the slabs are placed in piles on a carefully constructed platform. Not more than 5-6 slabs should be

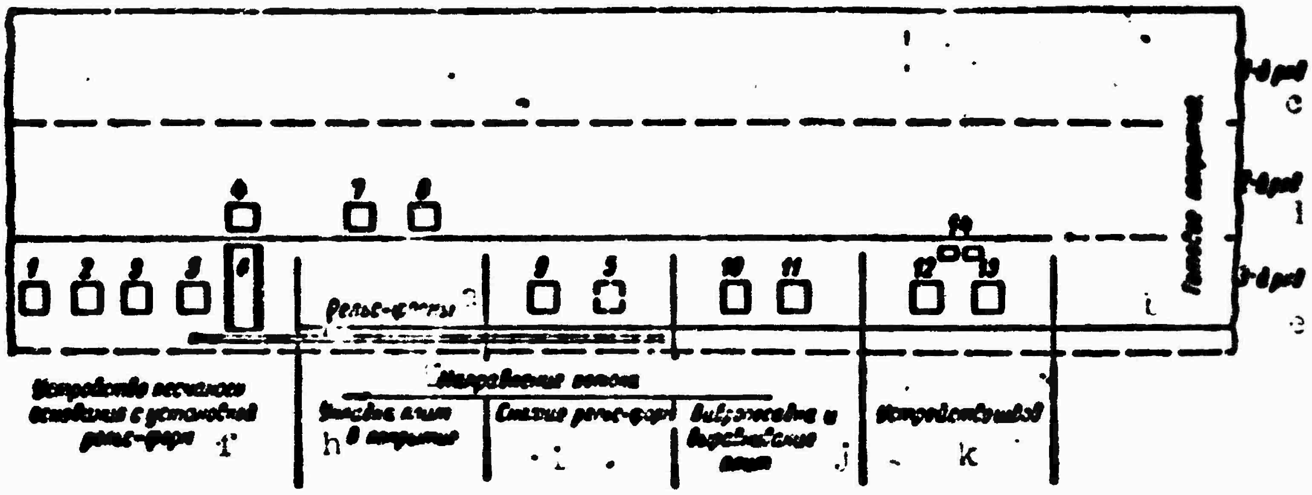


Fig. 117. Engineering arrangement for assembling a pavement. 1) Damp truck (trucking in of sand); 2) bulldozer (leveling the sand); 3) motor grader (rough grading); 4) water sprinkling machine (sprinkling); 5) crane (placing the paving forms); 6) subgrader (leveling and compacting the sand); 7) truck (hauling in the slabs); 8) crane (placing the slabs); 9) truck (transporting paving forms); 10) crane (moving over the vibrating unit); 11) vibrating unit (settling and leveling the slabs); 12) electric welding apparatus (welding the joints); 13) joint sealing machine; 14) electrical brush and compressor; a) paving forms; b) finished pavement; c) 1st row; d) 2nd row; e) 3rd row; f) constructing the sand foundation and placing the paving forms; g) direction of flow; h) placing slabs into a pavement; i) removing the paving forms; j) vibrational settling and leveling the slabs; k) constructing joints.

placed one on top of the other in each pile, with separating wooden spacers 3-4 cm thick placed perpendicular to the long side of the slab. The lower place the pile is placed on 10-12 cm thick spacer.

After unloading, the slab sides are primed by priming mastic using a paint dispensing unit. For convenience in priming the distance between the piles should be not less than 0.8-1.0 meters.

The slabs are broughtto the point of placing by trucks: the PAG-III and PAG-IV slabs are hauled in by the ZIL-150 or ZIL-164 trucks, slabs PAG-XIV and PAG-XV are brought in by MAZ-200 trucks while seven ton trailers are used for the PAG-IX slabs.

The average productivity of trucks in hauling the slabs is given in Table 36.

The productivity of the trucks depends to a large extent on the state of the approach roads. Previously placed pavements should be max-

imally used for the movement of machines within the limits of the construction area.

TABLE 36

Дальность возки, км 1	Плиты ПАГ-III, ПАГ-IV (весом 2,8 т на бортовых автомобилях ЗИЛ-150 или ЗИЛ-164) 2	Плиты ПАГ-IX, ПАГ-XIV и ПАГ-XV (весом от 4 т и более на автомобилях МАЗ-200 или с полуприцепом ММЗ-584) 3
	4 Количество плит, перевозимых за одну смену, шт.	
3	35	25
10	12	10

1) Hauling distance, kilometers; 2) PAG-III and PAG-IV slabs (weighing 2.8 tons on ZIL-150 or ZIL-164 side panel trucks); 3) PAG-IX, PAG-XIV and PAG-XV slabs (weighing from 4 tons and more on MAZ-200 trucks or with the MMZ-584 semitrailer); 4) number of slabs hauled per shift, pieces.

68. CONSTRUCTING THE SAND FOUNDATION

At the present time the sand foundation is the most widely used kind of main-made foundations, which, alongside with other positive qualities, ensures comparatively tight contact with the slab. Sand foundations present the smallest resistance to temperature induced displacements of pavement slabs, and also do not lose strength when wetted in the most unfavorable times of the year.

The sand foundation should, as a rule, be constructed by using the D-345 subgrader. The work for constructing the sand layer consists in filling and preliminary leveling of the sand layer, placing the paving forms, compacting and finishing the sand layer. Filling and preliminary leveling of the sand layer do not in any way differ from operations performed in constructing monolithic concrete pavements.

Furrows 0.5-0.8 meters wide are prepared for placing the paving forms on the sand layer. The sand in the furrows is leveled, sprinkled if necessary to obtain maximal moisture and compacted by surface vibrators.

When constructing a leveling layer on a foundation the paving forms are placed directly on the man-made foundation. The paving form sections are installed by the K-32 truck crane. Jacks and clamps serve as devices for placing, leveling and connecting the sections.

The proper placement of paving forms is checked by a leveling instrument at each joint. After the paving forms are fastened to the foundation, the subgrader makes a trial pass and the leveling is repeated. Here the deviation from elevations should not exceed 3 mm. The thickness of the sand layer filled between the paving forms is checked simultaneously with checking the paving form placement. Final leveling out, compaction and finishing of the sand layer are performed by the D-345 subgrader.

The productivity of the D-345 subgrader is up to 2000 meters^2 per shift. The team consists of 15 workers. An approximate list of mechanization facilities in constructing a sand foundation is:

D-345 subgrader with a 600 linear meter set of paving forms	1
KPM-1 water sprinkling machine.	1
K-32 truck crane	1
D-271 bulldozer	1
D-144 (265) motor grader	1
ZIL-150 truck	1
I-117 vibrators	2
220/36 V, 1.5 kwt transformers	2
PES-15 portable electric generator unit	1

When constructing a leveling layer from sand and cement, the latter are usually mixed directly on the man-made foundation. The sand moisture should not exceed 5-6% and the time interval between mixing and placing the slabs should not exceed 4-5 hours.

To construct foundations for individual sitting places [aprons]

use is made of hand templates, guiding rail molds and surface vibrators. Work is performed in strips not wider than 12.5 meters.

69. PLACING THE SLABS INTO A PAVEMENT

The airport pavement slabs are placed in rows in the direction of the longitudinal axis of the runway. The row width is taken as approximately 6.0 meters. The slabs are placed into a pavement with their long side along the principal direction of aircraft movement.

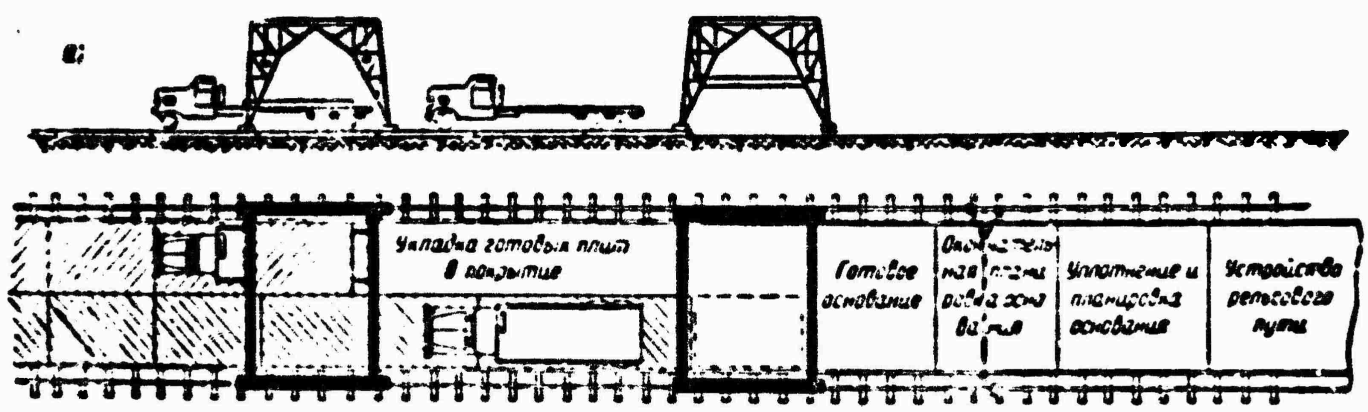
Before the precast slabs of reinforced concrete pavements are placed, the pavement should be set out in the plan. The elevations are checked directly in the process of placing the slabs by a leveling instrument and a rod with a level.

Slabs such as PAG-IX are placed by a 25 ton capacity crane (K-252) all the remaining slab types are placed by the K-102 or K-103 cranes. The K-102 (Fig. 118b) has a rating of 10 tons for a boom radius of 4 meters and of 3 tons when the boom radius is 10 meters. The productivity of K-102 cranes in placing of slabs into a pavement is up to 800 meters^2 per shift.

The truck carrying the slab should be positioned so that the angle of rotation of the crane boom in the plan from the truck to the point of placing be minimal. The slabs are placed from "the wheels" thus combining the unloading and placing operations. The slabs are placed in accordance to a stretched wire placed to one side of the row being placed. The joint width between adjacent slabs may not exceed 15 mm, and the height difference cannot be greater than 5 mm.

The slab should be lowered accurately, so that it touches the foundation simultaneously by its entire lower surface. The slab may not be moved in the horizontal direction after it was placed on the foundation, since this may damage the foundation. But, taking into account irregularities which exist even if the sand foundation surface

has been most carefully leveled, it is practically impossible to lay a slab in its place in one trial. In order to check the correctness of the slab's placement, it is placed in position and the force is removed from the cable for 20-30 seconds. Then the slab is raised and the tightness with which it adhres to the foundation is checked by the impression it made on the sand. If necessary, microscopic irregularities of the foundation are corrected whereupon the slab is replaced in position. It is sometimes necessary to repeat these operations up to 3-4 times. In order to provide for safety of work when correcting the foundation surface, the slab should be moved by 3-4 meters to a side.



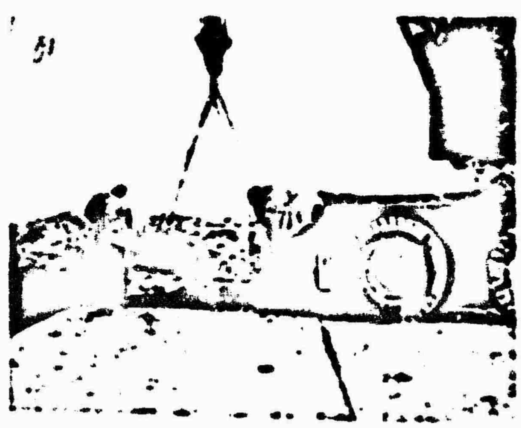


Fig. 118. Placing of slabs. a) Engineering arrangement for placing of slabs by gantry cranes; b) placing of slabs by the K-102 crane. 1) Placing of precast slabs into a pavement; 2) finished pavement; 3) final grading of foundation; 4) compacting and grading the foundation; 5) constructing tracks.

In order to ensure that the slab be in horizontal position when lowered onto the foundation the cranes are equipped with special holding devices. One of these devices is a rectangular crosspiece with hooks on cables or chains at the corners. When the slab is placed the pavement evennes is checked by a 3 meter rod. The rods should be put

to a previously placed slabs and to the new one, still held in the holding device.

After placing two slabs the crane drives onto them, whereupon a final check is made of the vertical position of the slabs.

After slabs have been placed on a 10-15 meter section they are compacted by pneumatic-tired rollers or by vibratory self-propelled rollers. The above technique for placing slabs into a pavement is very labor consuming.

In order to eliminate slanting when lowering onto the foundation the slabs can be placed by two self-propelled gantry cranes which move over rails (suggested by A.N. Zashchepin). The gantry crane removes the slab from the truck and moves it in the suspended state.

The numerous raising and lowering operations are being eliminated by adapting the vibration method for seating the slabs. In this case after slabs have been placed in a section 50-60 meters long they are seated and leveled by a vibrating unit.

The vibrations result in obtaining tight contact between the slab and foundation.

The vibrating unit is placed by the K-102 crane on each slab in sequence. The vibration time at one position is 40-80 seconds. The settling of the slab after vibration comprises 10-12 mm. The second vibrating unit pass ensures final leveling of the slabs.

For leveling the slabs (where not properly seated) the vibrating unit is placed on the joints. After leveling, the pavement is rolled by 2-3 passes of a loaded MAZ-200 or YaAZ-210 truck. Height differences between adjacent slabs after rolling may not exceed 3 mm.

It must be pointed out that the evennes, even when using the vibration seating method, depends to a large extent on the accuracy with which the slabs are produced and on the quality of grading and prelim-

inary compacting of the foundation.

In order to ensure an even pavement surface, V.M. Mogilevich has suggested to change the techniques used in the work. According to the system suggested by him the slabs are placed in the exact design position in the suspended state and then sand is supplied under them.

It is recommended that the sand be supplied by the hyfraulic methof, mechanically or by blowing with compressed air. The stability of precast slabs can also be improved by supplying cement grout under pressure under the slabs. This method is advantageous for slabs with a bracket shaped profile of the lower surface.

70. CONSTRUCTING JOINTS

The work of joint construction consists in operations for cleaning the joint from dust and dirt, welding the joint connections, second cleaning of the joint and sealing them with mastic. The dirt, dust and sand are first cleared of sand and the joint brackets are cleaned from rust by metal hooks and steel brushes. The joint elements are connected by welding. Welding units such as SAK-2, G-1, SAK-25 and other are used for welding. The welding electrodes should be specified by the design (usually of type E-42A or E-34).

The average productivity of a welding unit per shift is up 320 m^2 of pavement. If the gap between the brackets being welded is up to 4 mm, then the welding is performed in a single continuous seam. If the gap is wider than 4 mm an additional steel bar whose diameter is 2-3 mm greater than the gap width is placed on the brackets and the brackets are welded by two parallel seams.

The welding should be performed in strict conformance with the applicable specifications for welding operations. After welding the joint connections the pavement is rolled by 2-3 passes of a fully loaded MAZ-200 or YaAZ-210 truck. Joints with damaged seams are rewelded.

Before filling the joints the vertical walls are again cleaned of dust, dirt and sand. The cleaning is done by cylindrical and disk brushes which are placed in sequence on the D-378 electric brush. The final operation of joint cleaning is blowing them through with compressed air from hoses of the VKS-A5 self-propelled compressor of the PKS-6M portable compressor Immediately after cleaning the joints are filled with TsN-2 mastic heated to 170°. The joints are filled by the D-344 joint sealing unit. The mastic is prepared in D-124A portable bitumen boilers.

The productivity of main operations in constructing joints is given in Table 37.

TABLE 37

1 Наименование работ	2 Плиты		
	3 ПАГ-III 4 и 3 ПАГ-IV	3 ПАГ-XIV 4 и 3 ПАГ-XV	3 ПАГ-IX
	5 Производительность, м²/смену		
6 Очистка швов электрощеткой Д-378	2000	2100	3700
7 Продувка швов компрессором ВКС-А5	3400	4000	5100
8 Заливка швов заливщиком Д-344	200	310	510

1) Designation of operations; 2) slabs; 3) PAG; 4) and; 5) productivity, m²/shift; 6) cleaning the joints by the D-378 electric brush; 7) blowing the joints through by the VKS-A5 compressor; 8) sealing the joints by the D-344 joint sealing unit.

The quality of all kinds of operations should be controlled in accordance with applicable technical specifications.

Chapter 10

CONSTRUCTING PREFABRICATED METAL PAVEMENTS

71. CHARACTERIZATION AND COMPOSITION OF OPERATIONS

Metal pavements are used at airports for agricultural, sanitation and forest aircraft, and also at temporary airports in regions where large industrial enterprises and hydraulic installations are being constructed.

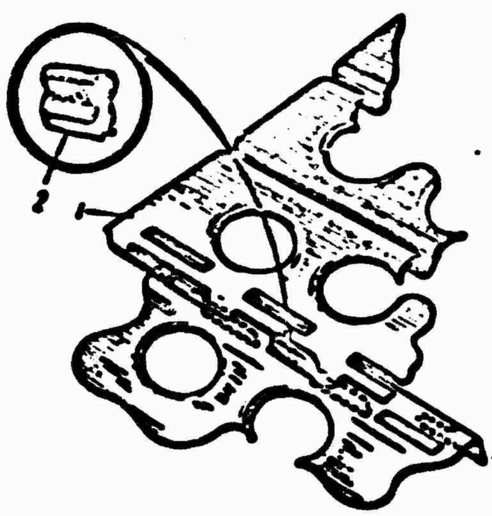


Fig. 119. Details of an attachment for pierced planks. 1) Prefabricated pavement; 2) spring look.

The pavement planks are fabricated by cold stamping from 08KP sheet steel. To increase their rigidity, the planks are designed with longitudinal ribs. The PMP-1-53 planks are pierced by 50 mm holes in planks such as MP-1-51 are replaced by spherical bylges in the lower and upper flanges.

The planks are interconnected by a standard attachment made from hooks and slots situated along the edges of each plank. The attachments are held together by spring locks, three per a longitudinal plank edge (Fig. 119).

The PMP-1-53 and MP-1-51 planks are interchangeable, since their geometric dimensions and the attaching connection designs are the same.

The MP-2-51 planks are box-like in cross section. The planks are interconnected by a one-sided, dowel-less attachment. The attachment is locked by pressing the back side of hooks into special clamping de-

vices.

The connection of K-1 planks is also one-sided and dowel-less. The ends of the plans being connected are fastened by end planks.

In placing the planks care should be taken that the pavement joints alternate which is achieved by displacing adjacent rows of planks by a half-plank. To even out the longitudinal pavement edges, the set, in addition to full planks, also has half planks. The comparative characterization of metal planks assimilated by our industry is given in Table 38.

TABLE 38

Тип плит 1	Габаритные размеры плиты, мм 2			Укладочные размеры, мм 3		Толщина листа, мм 4	Момент сопротивления плиты, см³ 5	Полезная площадь плиты, м² 6	Вес плиты, кг 7	Количество плит в пачке, шт. 8	Вес пачки, кг 9	Возможность извлечения отдельной плиты из покрытия 10
	длина 11	ширина 12	высота профиля 13	ширина 11	длина* 14							
Перфорированные старого образца 14	3041,5	411	21	381	3018	3—3,5	1,93—2,27	1,16	27—32**	30	820—970**	Извлекается 15
МП-1-51 16	3042,4	411	21	381*	3018	3	2,0	1,16	30	30	910	17
МП-2-51	3034,0	436	23	390	3040	2,5	7,8	1,19	30	20	610	Не извлекается
ПМП-1-53 18	3042,4	411	21	381	3018	3	2,00	1,16	28	30	850	Извлекается
К-1	3060,0	452	31	420	3000	3	14,1	1,26	42	20	850	15

*Taking into account the spaces between the planks; K-1 planks taking into account the overlapping of ends.
**Depending on the thickness of the steel sheet.

1) Plank type; 2) overall dimensions of plank, mm; 3) placing dimensions; 4) sheet thickness; 5) the section modulus of plank, cm^3; 6) useful plank area, m^2; 7) plank weight, kg; 8) amount of planks in bundle, pieces; 9) weight of bundle, kg; 10) feasibility of removing an individual plank from the pavement; 11) length; 12) width; 13) height of profile; 14) old type piercing; 15) is removable; 16) MP; 17) is not removable; 18) PMP-1-53.

Foundations for use with metal pavements are made from optimal soil and gravel mixtures, macadam gravel and soil foundations treated with an organic binder.

The types of the man-made foundation for the design aircraft load is chosen depending on the hydrogeologic and climatic conditions of the construction region, with mandatory consideration of the use of

local construction materials.

In individual cases under favorable hydrogeologic and soil conditions, the soil in its natural state can be used as the foundation.

The work of constructing metal pavements consists of the following production processes:

constructing the foundation;

loading and unloading and transportation operations;

setting out;

distributing the planks and assemblying the pavement;

fastening the edges and ends of the planks to the foundation.

The procedure for constructing man-made foundations was considered above.

The grading and compaction of foundations for metal pavements should be performed with particular thoroughness, in order to ensure contact of the entire bearing area of the metal planks with the dounda-tion surface. The transverse section of man-made foundations for metal runways and taxiways is usually of the crown-type, in order to provide for reliable water drainage.

72. LOADING AND UNLOADING AND TRANSPORTATION OPERATIONS

For convenience in loading and transportation, the metal planks and half-planks are staked in bundles. The planks are packed at the plant by four flat bars with lugs. Each such bar should be passed through the 8th hole in the plank counting from the end and in the 3rd hole of a half plank.

The metal planks are usually transported from the producing plant to the construction site warehouse on railroad flatcars. 18-22 plank bundles are placed on 16-20 ton capacity flatcars and 44-46 bundles are placed on 50-60 ton capacity flatcars.

Side supports 10-18 cm in diameter with a wire stay of 3-5 mm dia-

meter wires fastened to them are constructed on the flatcar.

The metal panks are unloaded from the rail ad flatcars and are loaded onto transportation facilities by truck cranes with a special rigging device (Fig. 120).

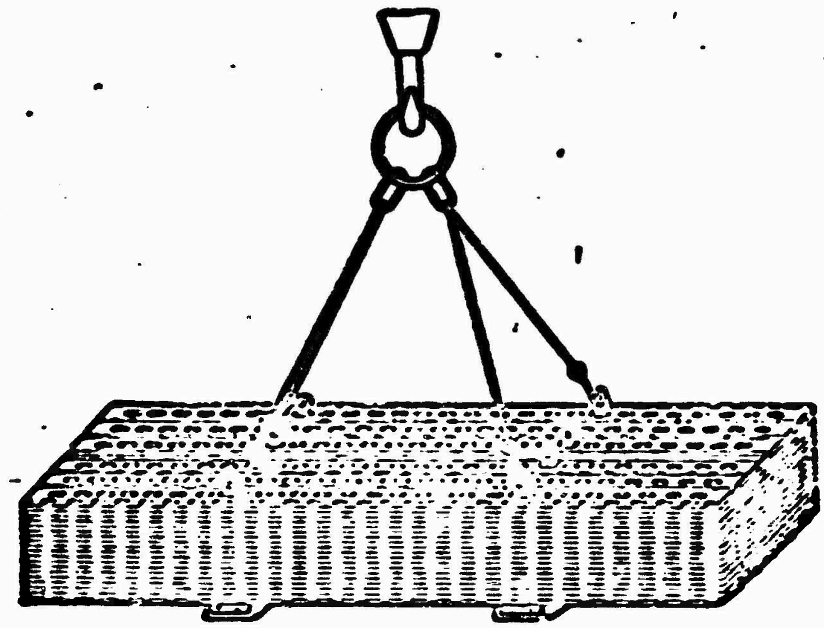


Fig. 120. Rigging devices for loading and unloading plank bundles.

The unloading platform should be prepared in time and should be well lighted.

The metal planks are transported from the railroad station to the construction area by side panel trucks, truck trailers and tractor trailers.

For calculating the transportation facilities needed, the amount of plank bundles loaded onto trucks can be taken from Table 39.

The planks should be transported over paved and dry soil roads, as a rule, in trucks with trailers. If, in addition to trucks, tractors are used for transporting the planks, two roads are constructed to the construction site, one of which (a soil road) is made specially for tractors with trailers.

It is recommended that control and dispatching points be organized for controlling the timely delivery of planks to the construction

site, keeping count of the planks and controlling their unloading at specified points.

TABLE 39

1 Марка автомобиля	2 Грузоподъемность, т		3 Количество нагружаемых пачек плит			
	4 без прицепа[1]	5 наибольший вес буксируемого груза в прицепе (по шоссе)	6 в кузов автомобиля без прицепа	7 на автомобилях с прицепом[2]		
				8 в кузове	9 в прицепе	10 всего
ГАЗ-63 11	[illegible].5/2.0	2.0	2	2	2	4
ГАЗ-51 11	2.0/2.5	3.5	2	2	2	4
ЗИЛ-150 12	3.0/4.0	4.5	4	3	3	6
ЗИЛ-151 12	2.5/4.5	3.6	4	3	3	6
ЗИЛ-585 12	—/3.5	—	4	—	—	—
МАЗ-205 13	5.0/6.0	—	5—6	—	—	—
МАЗ-200 13	5.0/7.0	9.5	6—7	6	5	11
ЯАЗ-210 14	10.0/12.0	15	11—13	11	15	25

1) The numerator gives the capacity of trucks when m ving over soil roads, and the numerator gives the same information when moving over paved roads.
2) Transporting the planks on trucks with trailers is permitted, under ordinary conditions, only over paved or dry soil roads.

1) Truck brand; 2) capacity, tons; 3) number of plank bundles loaded; 4) without trailer; 5) the greatest weight of towed load in the trailer (over paved roads); 6) into the body of a truck without a trailer; 7) on trucks with trailers; 8) in the body; 9) in the trailer; 10) total; 11) GAZ; 12) ZIL; 13) MAZ; 14) YaAZ.

73. SETTING OUT

Before the metal planks are placed on the prepared foundation, the operations are staked out in accordance with the staking out drawing. The center lines of metal runways, taxiways, aprons and terminals are staked out by a theodolite and laid out by pegs each 20 meters. Temporary type III bench marks (See Fig. 1) are placed at the ends of the center line at a distance of 150 meters from the end of the metal runway. The longitudinal edges of the metal runway are set out by measuring off the strip width from the center line using a steel tape. Measurements should be made each 500-600, but in at least 3 points. The longitudinal edges of the strip are laid out by pegs and stakes. In addition, a theodolite should be used for marking off transverse

lines for leading rows of planks being placed at each section.

To control the correctness of placement a string or wire should be stretched along the edges of the strip on nails driven into the pegs.

To decrease the work in distributing the planks, the points where the planks are to be unloaded and stored are marked off by stakes at the locality. The plank bundles may be unloaded and placed directly on the prepared foundation or at the longitudinal edges of the strip.

74. DISTRIBUTING THE PLANKS AND ASSEMBLYING THE PAVEMENT

The packed metal planks are unloaded at the construction area, and laid out in rows with the long sides perpendicular to the longitudinal axis of the metal runway. The planks are distributed manually using special hooks. When placing pierced planks such as PMP-1-51 the hooks of adjacent planks should face opposite directions. The rate at which the planks are laid out should be such that the operations be approximately 0.5 hours ahead of the pavement assembly work.

In order to ensure a continous pace, the distributors should lay each tenth row in two layers. This is made necessary by the fact that during assembly of the pavement the distance between placed and provisionally laid out planks increases by approximately the width of one plank each 10 planks.

The laying of PMP-1-53 and MP-1-51 planks begins with laying two guiding rows which are placed exactly by theodolite. The planks are immediately coupled together by dowels and are fastened to the foundation by pegs.

After the guiding rows have been placed the following rows are assembled in one or both direction. Adjacent plank rows are laid by moving to the right or left through 2-3 planks.

The plank laying team consists of 4 workers. Two workers insert

the hooks of the plank being laid into the slots of previously placed planks and move them as far as they will go over the entire length of the projecting part of the hook. The third worker at this time should hold, by an assembly crowbar, the previously placed row of planks in the same plane with the row being placed. The fourth worker fastenes the plank by 3-4 dowels. The fastening worker should not be behind the placing workers by more than one plank. The productivity of this team is 800-850 planks per shift.

The pavement is assembled in one direction by a brigade composed of teams of workers bringing up and laying the planks and workers charged with fastening the edge sections (Fig. 121). The brigade usually has several teams of placing workers, 9-12 meters of the pavement width being assigned to one team.

The metal pavement is usually assembled simultaneously in several sections. The choice of the number of section depends on the specified construction schedule and on the availability of working force. The assembly can be performed by diverging, converging and inrunning sections (Fig. 122).

Two converging sections hould be joined by normal joining of hooks of one row with the slots of the other. In order to obtain complete convergence of converging (or running in) sections, use is made of design gaps provided for in the plank attachments. In order to ensure and accelerate the work in connecting of converging or funning in sections, it is convenient to join the planks by a curved plank (Fig. 123).

When the pavement is assembled in a number of sections, strict geodetic checks must be kept, not allowing the plank placement to deviate from the center line of the strip.

For joining of taxiways to the metal runways the connecting joint

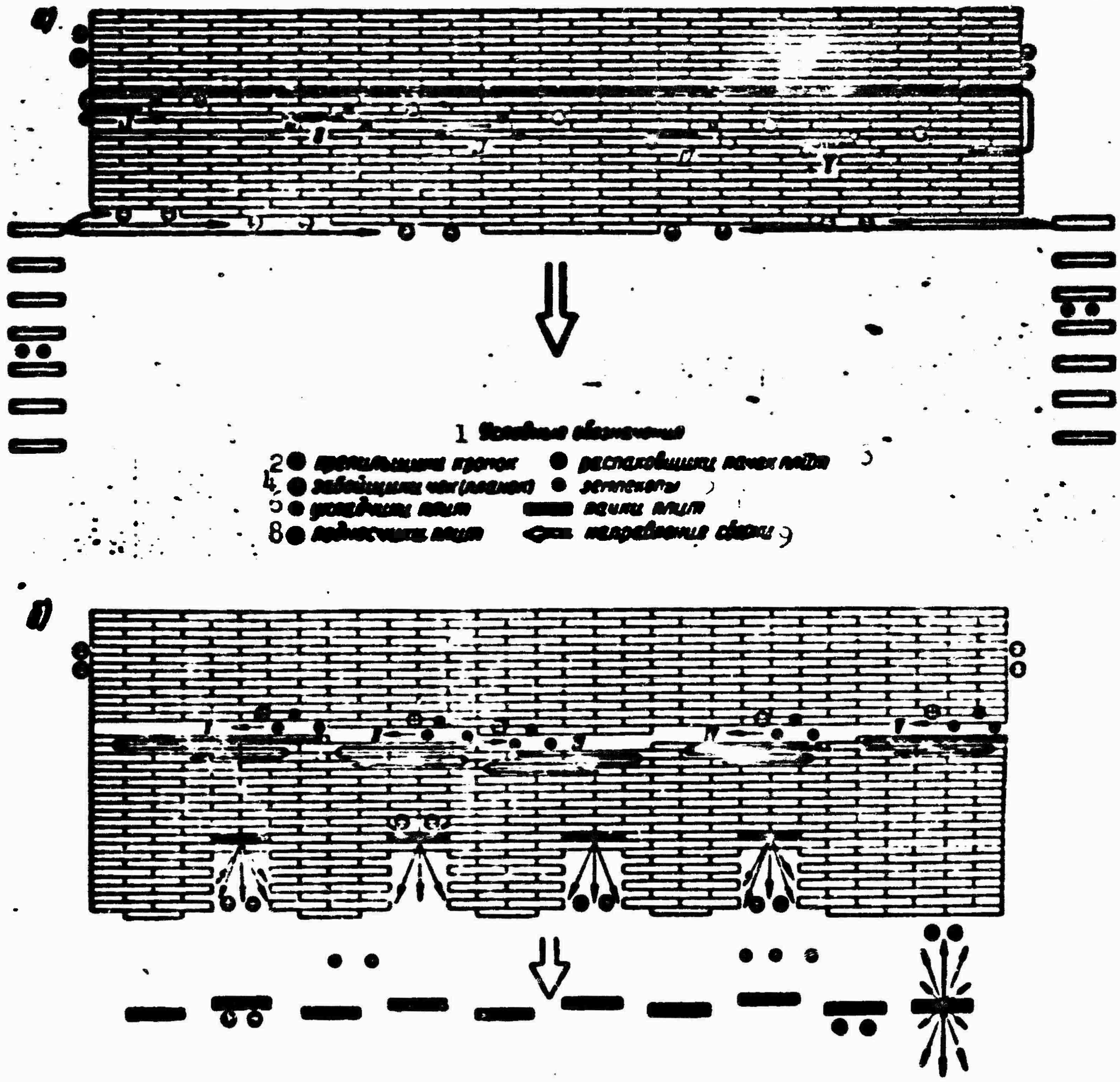


Fig. 121. An example of organizing the placing of metal pavement planks into a continuous section. a) Through placing (in the upper part of the diagram, up to the heavy line is shown a finished pavement, below this are shown provisionally placed planks); b) placing in sections (the upper part of the diagram up to the spacing shows a finished pavement, below are provisionally placed planks); 1) Legend; 2) edge fastening workers; 3) workers unpacking the plank bundles; 4) workers inserting the dowels (bars); 5) earth diggers; 6) workers placing the planks; 7) plank bundles; 8) workers bringing the planks; 9) assembly direction.

is covered by one layer of planks which is welded to the plates of the metal runway. It is also permissible to fasten the joints together by splices of 4-5 turns of 3-5 millimeter wire each 75-100 cm. In this case the corners of the plates must be fastened and the splices must

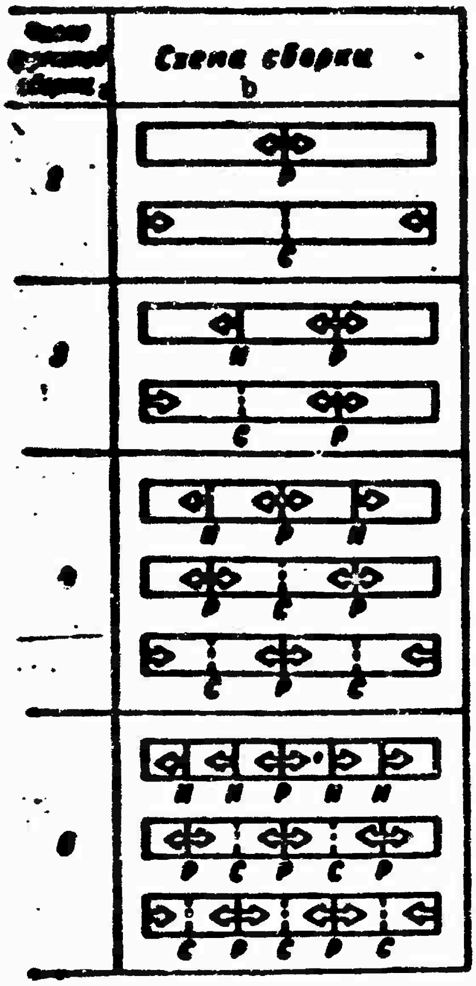


Fig. 122. Schemes for multi-section assembly of a pavement. P) is a diverging section; C) is a converging section; H) is a running in section; a) number of assembly sections; b) assembly scheme.

be bent underneath the plank.

To ensure good contact when laying a metal pavement from planks such as MP-2-51, it is first necessary to loosen the foundation surface to a depth of 3-5 cm. The planks are placed by moving to the left taking into account that the attaching joint is at one side only. When placing planks in two sections from the middle the guiding rows are connected by welding. The first row of planks is immediately fastened to the foundation by wooden pegs, which are driven into the ground through precut holes in the plank.

To assemble the following planks, the edges of the plank being placed are inserted in the slots of a previously placed plank, and then the plank is moved as far as it will go and is then left. The plank is locked without dowels.

If the placing has been performed properly, the gaps between planks in the rows should not exceed 5-6 mm.

To interconnect metal planks such as K-1 the hooks of planks of the row being placed are introduced into the slots of previously placed planks and are moved by the length of the hook travel, which is controlled by positioners. When the plank is lowered onto the foundation, the positioners of previously placed planks should freely fit into the corresponding holes in the perforation of the plank being placed. The ends of the planks being joined are fastened by special

bars which are inserted into the end slots.

Complete convergence of the extreme rows of planks of two adjacent sections is achieved by taking up the gaps in perforations and slots.

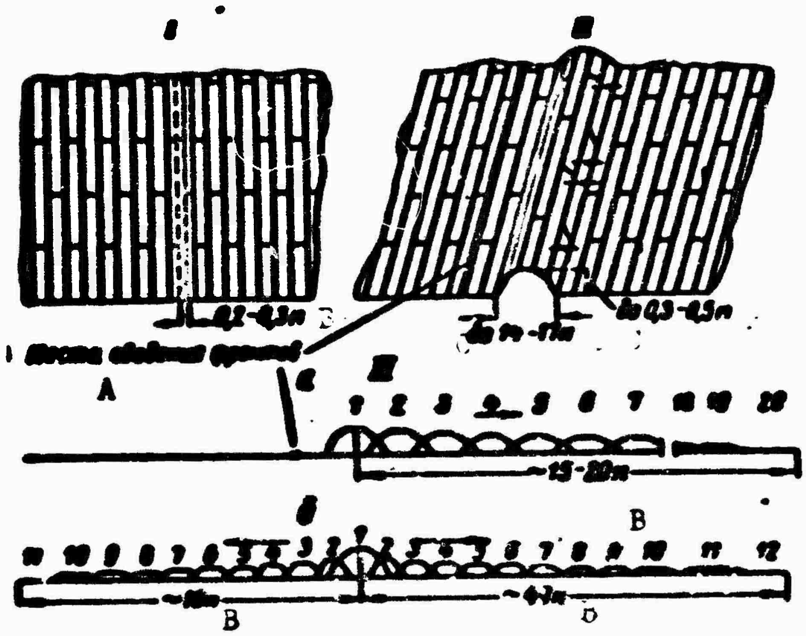


Fig. 123. Scheme of joining two converging sections by a curved plank. I) Position of planks before forming the curved plank; II) general view of the curved plank after the section are joined; III) scheme of the curved plank; a) in one direction; b) in both directions; A) points at which the sections converge; B) meters; C) up to.

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75. FASTENING THE EDGES AND ENDS OF PLANKS

The finishing stage in assemblying the pavement is fastening the side edges and ends of the metal runway to the foundation.

Triangular cross section trenches 30-40 cm deep are dug along the pavement in order to fasten the plank ends. The planks are fastened each 3 rows to the fourth by wire splices to the anchors. The anchors are driven into the soil so that their upper ends be not less than 8-10 cm from the flying field surface.

The ends of metal runways are fastened by submerging the extreme 3-4 rows of planks into the soil at a 45° angle to the earth's surface. The planks are placed into a trench with triangular cross section dug for this purpose and are fastened to the earth by anchors.

After fastening the trenches and ditches are filled with soil which is thoroughly compacted.

The required tools and implements for assemblying a metal pavement are the following:

Gas welding apparaturs, pieces.	1-2
Theodolite, pieces.	2
Leveling instrument, pieces	1
Pegs, pieces.	100
Leveling rods, pieces	4
Measuring tapes (20 meters), pieces	2
Metal reel tapes, pieces.	10-15
Iron wire, 3-5 mm in diameter, annealed, tons . . .	25-30
Skid, poles 7-8 cm in diameter, m^3.	35-40
Staking out string, linear meters	1000-2000
Rigging devices per each truck crane, pieces. . . .	2

The rapid development of the chemical industry makes it possible to replace the metal with plastics, which are much lighter and which will cost less than the metal planks.

76. CONTROLLING THE QUALITY AND ACCEPTING THE WORK

The measurements and direction of the metal runway are checked systematically during assembly of the pavement. In order to ensure correctness of the strip direction, the planks should be placed in accordance with a staking out rope, stretched along one edge of the strip.

If the center line of the pavement being placed has been displaced to one side, these displacements must be reduced to approximately the lead of the hooks and then to displace each row by one hook in a direction opposite to the displacement of the center line.

In assemblying planks such as the K-1 care must be taken that the positioners slide into the corresponding holes in the plank perforations.

Of great importance is the tightness with which the planks adhere to the foundation, for which reason overhanging sections cannot be

tolerated.

The presence of the required amount of end bars in each plate and the stability of fastening them is checked in the case of K-1 planks. For the remaining plank types checks are made of the presence of the necessary amount of dowels in each plank.

An acceptance and surrender act is made our for the finished metal plank pavement.

Chapter 11

LANDSCAPING OPERATIONS

77. CHARACTERIZATION AND COMPOSITION OF LANDSCAPING OPERATIONS

All sections of airports not occupied by installations are subjected to covering with sod. This extensive use of the sod cover is due to its high service qualities, low cost (in comparison with other types of man-made pavements) and the feasibility of complete mechanization of operations for creating the sod cover.

The sod cover on the flying field should be formed by plants capable of producing a uniform and thick herbage, which grows agains after mowing and which restores the sod cover damaged by taxiing, acceleration and passage of aircraft.*

The methods and sequence with which the lanscaping operations are performed depend on the soil and climatic conditions, and the character of earth moving and grading operations that were performed. Of great importance are proper times for performing the different kinds of landscaping operations.

The producing of a sod cover at flying fields entails the following operations:

cultivating the soil;

introducing fertilizers;

sowing the flying field.

Before the landscaping operations start the flying field is broken up into individual strips (sections), which for convenience in work should be rectangular if at all possible. The strip dimensions are es-

tablished on the basis of ensuring the movement and turning around of the tractor unit.

In setting up the scheme for the movement of the tractor assembly it is required that the length of idle trips (driving in and turning at the strip's edges) should be minimal. The motion of assemblies in the strip should be by the pass method in which the tractor assembly makes rectilinear passes along the long side of the strip and the idle trips are made in the transverse direction.

The work for covering airfields with sod is performed in accordance with the plan of landscaping measures which are a part of the plan of organizing the work in constructing the flying zone of the airfield.

Presowing cultivation of the soil begins only after the entire integrated set of earth moving operations, including the restoration of the topsoil layer, have been completed.

78. CULTIVATING THE SOIL

The main task of presowing cultivation is loosening the upper soil layer, destruction of weeds, putting in of fertilizers and protection of the soil moisture. Cultivation consists of the following operations: plowing, harrowing and rolling. In addition to these it is also possible to use rototilling, which combines the operations of plowing, disking and harrowing.

The soil cultivation scheme is established depending on the soil conditions, character of earth moving operations at the given section and the kinds of fertilizers used.

Schemes of soil cultivation for sections with and without earth moving operations are presented in Table 40.

TABLE 40

Clay, podzolic and argillaceous soils	Podzolic, sand loam and sand	Black earth and chestnut soils (Clay and Argillaceous
Schemes of Soil Cultivation at Sections with Earth Moving Operations		
Plowing or loosening of soil	Removing and piling the topsoil	Deep loosening or plowing
Piling of topsoil	Earth moving operations	
Earth moving operations	Restoring the topsoil	Earth moving operations
Restoring the topsoil	Placing of fertilizers by disking	
Placing fertilizers by disking or shallow plowing	Rolling with a heavy roller	Placing fertilizers by a cultivator or disk harrow
Rolling with a heavy roller	Presowing harrowing	Rolling with a heavy roller
Presowing harrowing		Presowing harrowing
Soil Cultivation Schemes for Sections Without Warth Moving Operations		
Plowing with placing of fertilizers	Disking to a depth of 10-12 cm with placing of organic mineral fertilizers	Plowing with placing of fertilizers
Dressing the furrow by disking	Harrowing and minor grading	Dressing the furrow by disking
Harrowing and minor grading	Rolling with a heavy roller	Harrowing and minor grading
Rolling with a heavy roller	Presowing harrowing	Rolling with a heavy roller
Presowing harrowing		Presowing harrowing

Plowing

Plowing produces the most favorable conditions for accumulating in the soil of moisture and nutrients necessary for the springing up and development of seeds of sod producing grass. Plowing of the soil should ensure the creation of a loose plowed layer and complete submersion of weeds, organic and mineral fertilizers. Plowing is used at

sections where no earth moving operations were performed or, where after the earth moving operations were performed the soil remained unloosened. No plowing is performed at sections with a newly produced topsoil layer and at low-cohesion sand loam and sand soils (if the section is not seriously overgrown with weeds).

The plowing assembly is set up in accordance with the condition of the surface, the necessary plowing depth and the width of the plow coverage. The number of plow bottoms in the assembly is chosen so as to most completely utilize the tractor capacity. The soil is plowed by agricultural or brush plows.

In cultivating the soil by the method due to T.S. Mal'tsev use can be made of the PR-5-35Ts plow-cultivators.

The depth of main plowing at sections where earth moving work is not to be performed is established depending on local conditions. In nonblack earth and dry regions the plowing depth should be not less than 18-20 cm. The plowing depth in podzolic soil is only as deep as the topsoil layer. Plowing should be performed when the soil moisture is within the limits of 40-60% of the total moisture capacity, when the soil does not stick to the working surface of the implement and has not begun to dry.

When plowing in the spring and summer, harrows are usually coupled to the plow.

In dry regions, in order to accumulate moisture, the plowing, if possible, should be done in the fall.

The summer field is plowed by the pass (strip) method, either with the backfurrow on ridge or with dead furrow in the channel, and also with a decreased number of dead furrow channels and backfurrow ridges.

In plowing with the backfurrow on ridge (Fig. 124a) the unit en-

ters the strip at the middle of its narrow side, and the following working pass is performed in a row to the right side of the unit's path. In this method the plowed furrows will be directed toward the center, and a backfurrow is formed at the middle of the strip.

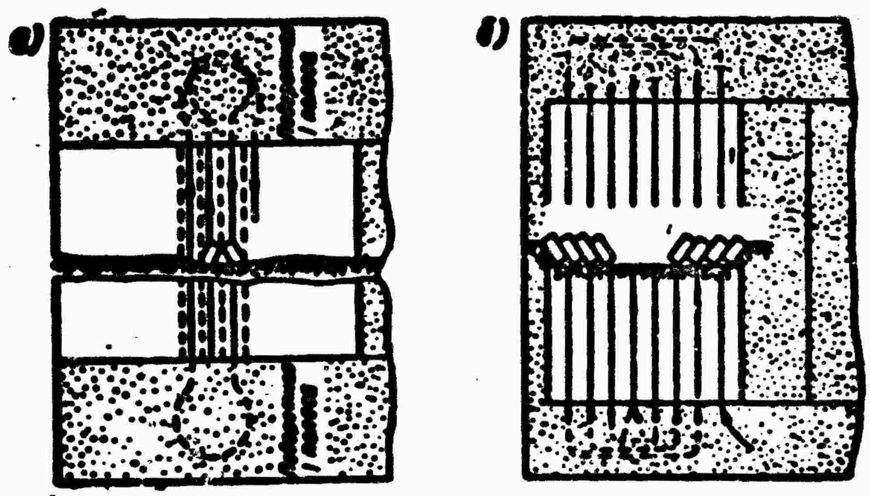

Fig. 124. Plowing. a) Back furrow on ridge; b) dead furrow in channel; 1) turning strip.

In plowing with the dead furrow in the channel (Fig. 124b) the unit enters the strip from its edge at the right side (from the edges toward the middle). In this method the plowed furrows will be directed from the middle of the strip toward its edges and a dead furrow channel is formed in the middle of the strip.

In order to decrease the number of dead and back furrows it is advantageous to plow three strips (Fig. 125). In this case first strips I and III are plowed by the backfurrow on ridge method and then strip II is plowed by the dead furrow in channel method. To place the furrows in one direction it is advantageous to use a reversible plow such as PO-5-35 which is designed to work with an electric tractor. After the entire section is plowed the turning strips are plowed by longitudinal passes. In order to decrease the length of idle trips, the plowing unit should be turned around with the smallest radius possible for the given unit.

As was noted, the summer field is plowed by rectangular strips. The strip length is assumed in accordance with the dimensions of the cultivated section and the width is determined depending on the length and composition of the plowing unit. The strip width should be a multiple of the unit's coverage width.

Before plowing starts the section on the flying field is marked off, and then a single bottom plow is used for plowing moderate depth control furrows and for digging first backfurrows at odd [numbered] strips along lines I-I and II-II.

The following requirements are put to the plowing quality.

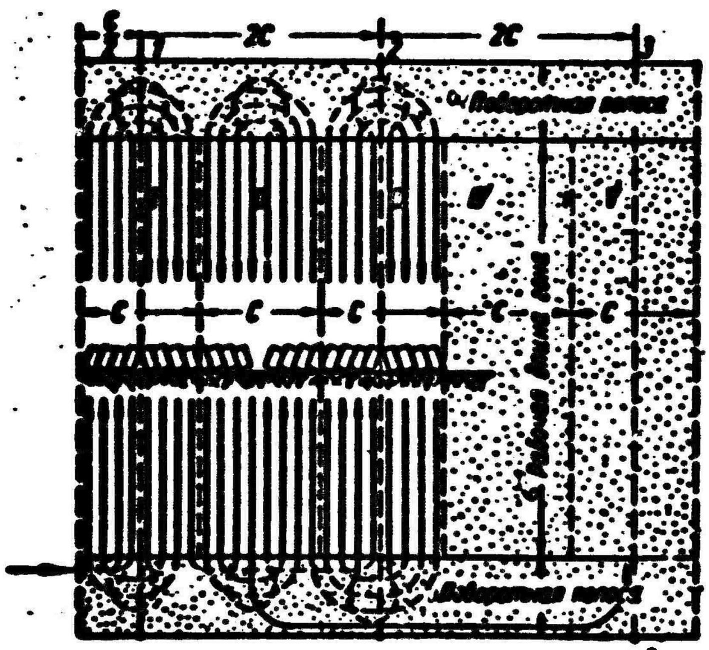

Fig. 125. Plowing with decreasing the amount of dead furrow channels and backfurrow ridges (C is the width of a strip). a) Turning strip; b) working length of pass.

Plowing should be performed in the established agricultural times to the given depth. Deviations may not exceed 1-2 cm.

The topsoil should bot be intermixed with the lower-laying soil.

The surface of the plowed section should not contain pieces of sod, vegetation or organic fetilizers.

Plowing should be performed in rectilinear furrows without flaws.

All the plow bottoms should give furrows of the same width and depth with a uniform comb-like shape.

The plowing depth is checked by a furrow measuring instrument or ruler at least 3 times per shift. The quality of furrow turning, absence of flaws, submersion of remaining vegetation and fertilizers are checked during plowing by inspection. Discovered shortcomings must be immediately eliminated.

Disking

Disking is used after plowing for dressing dense, cohesive furrows and for presowing cultivation at fatty and highly dense soils. In addition, disking can be used for primary cultivation of low-cohesion light soil instead of plowing.

Disking results in loosening of soil without turning the cultivated layer, and also in freeing the soil of roots and vegetation root systems. Disking is performed by tractor disk harrows such as BD-3,4 and heavy disk cultivators.

The depth of cultivation by disk harrows is up to 12-14 cm and for heavy cultivators it is up to 15-18 cm. The disking depth is adjusted by loading and moving a lever which changes the angle formed by the disk bank axis with the direction of motion. In cultivating sod and peat layers good results are obtained by disk harrows with serrated (star-shaped) disks.

Disking should be performed at the same soil moisture as plowing, i.e., within the limits of 40-60% of the total moisture capacity.

For convenience in disking, the strip width should be not less than 150-200 meters. The unit moves in passes by the shuttle scheme. The first disk harrow pass is made in the direction of the plow motion and all the following passes are made in the transverse direction. The number of passes is established depending on the soil state. Usually

2-3 passes suffice for dressing of furrows. 3-4 passes are needed in hard soils. In dressing of virgin soil after forest clearing the number of disk harrow passes is increased to 4-6 and more.

In addition to disk harrows, various cultivators are used for loosening and mixing the soil.

Tooth-type cultivators, with the teeth properly chosen and seated, ensure high quality of intermixing of soil particles. Before the work start the operating order of the teeth and the sharpness of their cutting edges must be checked. Tooth-type cultivators are frequently used for application of mineral fertilizers.

Harrowing

Harrowing serves for additional cultivation of the surface of plowed soil and for preserving the soil moisture. Harrowing is also used for application of mineral fertilizers and seeds of sod cover producing grass.

Harrowing is performed by tooth-type harrows as an operation supplementary to plowing in an integrated unit and as an independent operation.

In addition to tooth-type harrows, it is also possible to use knife, spring and disk harrows.

The coverage of one harrow section comprises about 1 meter, due to the insignificant specific resistance of harrows, the width of coverage using a powerful tractor can reach 50 meters. In this case use must be made of a special light extension coupling. The unit can be assembled for harrowing in 2 traces. The coverage width when working with the S-80 tractor will be 25 meters.

Harrowing, as well as plowing, is performed with the soil at appropriate moisture, since excessively moist soil will not loosen but will be smeared, while insufficient moisture will result in excessive

dusting. In both cases the soil structure becomes poorer and the productivity of labor is also decreased.

Harrowing is usually performed by the pass method by the shuttle scheme. Good results are obtained by diagonal harrowing, since due to the at an angle action of the harrow, the furrow loosens better.

The cross diagonal method of motion is used for harrowing of a flying field by two traces using a unit with harrows in a single line.

In order to eliminate flaws, the paths should overlap by 10-15 cm.

After harrowing the soil should acquire a fine lump structure and a leveled surface. If the surface obtained after harrowing is not sufficiently level, additional smoothing is performed. Smoothing is done by specially made wooden or metal rakes or by the back sides of harrows.

Rotatilling

Rotatilling performs deep and fine loosening of soil, and also applies fertilizers and other additions for improving the soil. Rotatilling combines plowing, cultivation and harrowing operations which are performed by using working elements in the shape of knives or hooks fastened to a drum. The depth to which the soil is cultivated is from 3 to 23 cm. When the drum rotates the working elements loosen the soil throwing it backwards to the hood walls. Hitting the hood, the loosened soil falls downward and is laid behind the rotary tiller in a uniform loose layer.

Rotatilling on mineral soils not extensively covered with sod is performed immediately to the required depth. In cultivating heavy soils with an extensive sod cover by the FB-1,9 rotary tiller, a layer 12-14 cm deep is cultivated first and the second pass is produced to the total depth (of 18-20 cm). If possible, a time interval should be established between the first and second passes of the tiller, in order for

the soil to be aerated and dried.

It must be noted that cultivating by a rotary tiller changes the soil structure to a considerably smaller extent than cultivating of a furrow by plowing with subsequent disking and harrowing.

<u>Rolling</u>

Rolling is performed for leveling and compacting the surface after harrowing. In compacting the soil favorable conditions are also produced for raising the moisture to the surface by capillary action. Rollers are used to roll sowed seed to place them into contact with soil particles.

Depending on local conditions, soil is rolled by smooth rollers weighing up to 4-5 tons and more and by sheepsfoot rollers.

Lighter drawn rollers are used for rolling of surfaces of heavy soils and medium and heavy smooth drawn rollers are used in light soils. Seeds are usually inserted by light wooden rollers weighing 0.2-0.3 tons.

To maximally preserve the moisture in dry regions it is expedient to perform the rolling by sheepsfoot rollers.

The soil moisture for rolling should be the same as for plowing. Very loose soil is first rolled by light and then by heavy rollers.

The flying field surface, as a rule, is rolled by a single pass.

79. INTRODUCING FERTILIZERS

The main tasks of presowing fertilization is increasing the amount of nutrients and also improving the physical properties of the soil.

Deficiency of nitrogen, potassium and phosphorus in the soil weakens the vegetation, slows down its growth, they cluster poorly and die rapidly. Of special importance is providing the grass with nutrients during the first year of their growth.

The following can be used for fertilizing the soil at airports:

local organic fertilizers (manure, well decomposed nonacid low layer peat and various composts);

artificial mineral fertilizers (nitrogen, phosphorus and potasium).

For better assimilation of direct nutrients in acid reactions, the soil is treated with lime. Use is made for this purpose of ground limestone ground dolomites, marl, chalk, lime, etc. The lime treatment also improves the physio-chemical properties of the soil. Salinity and alkalinity of soil are fought by treating it with gypsum.

Applying Organic Fertilizers

Manure is considered the most valuable organic fertilizer since it contains all the basic elements needed for nourishing the vegetation. But due to the limited feasibility of obtaining manure, peat is extensively used as a fertilizer in airport construction. Not too well disintegrated acidic upper layer peat should be made into compost by mixing with manure, phosphorus flour, lime and other materials. Well decomposed nonacid low layer peat can be used as a fertilizer without producing a compost. Before applying to the soil, the peat prepared for fertilization must be aerated during 10-15 days to decrease its moisture content and to oxidize ferrous salts which it contains which are damaging to vegetation.

In preparing the compost a peat layer 20-30 cm high is spread on a level area, which is then covered by a uniform layer of phosphorus flour or manure. Then the following peat layer is spread which is again covered by additives, which process is repeated untill a height of 1.0-1.5 meters is obtained. The length of the pile is from 10 to 30 meters and the width at the base is up to 2.0-2.5 meters.

In producing composts with phosphorus flour 1 part of phosphorus flour is used for each 40-60 parts of aerated peat (by weight). In producing composts with manure 1 part of manure is used for each 4-5

parts of well decomposed peat (by weight).

The compost should be applied in the spring or early summer, since the most active biological activity takes place in the summer. The time for preparing compost with manure is 10-12 months and with phosphorus flour it is 2-3 months.

The peat with the additions is intermixed when placing the compost piles. The fertilizers are applied to the soil at the same time it is cultivated.

Organic fertilizers are spread by the TUR-7 tractor-drawn general purpose spreader (Fig. 126) or by the NT-2 and NT-1 manure spreaders. Loaders NN-0.3 and NN-0.75 whose working elements is a hay fork or bucket, are used for loading the fertilizers.

The fertilizers are applied by disk harrows, rotary tillers or other implements uniformly to the entire depth of the fertilized layer which is taken as 10-12 cm for clay soils and 15-18 cm for sandy soils. Approximate rates of fertilizer application comprise:

Of manure:

in soils with a low humus content. . .	40-50	tons per 1 hectare
in soils devoid of humus	70-100	tons per 1 hectare

Of well decomposed peat:

in sandy soils	200-250	meters^3/hectare
in clay and heavy argillaceous soils .	150-200	meters^3/hectare
in light clay and argillaceous soils .	100-150	meters^3/hectare
of peat compost.	from 50 to 100	tons/hectare

Applying Mineral Fertilizers

The selection of kinds of mineral fertilizers depends on local soil and climatic conditions, the agricultural state of the section to which the fertilizers are being applied and the properties of the fertilizers proper.

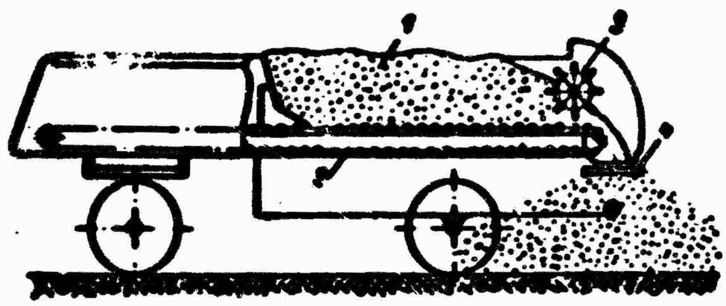

Fig. 126. Diagram of the operation of a fertilizer transporting and spreading machine. 1) Fertilizer; 2) conveyer; 3) drum; 4) spreader rotor.

The following are most frequently utilized as soil fertilizers at airfields: ammonium sulfate, ammonium chloride, calcium cyanamide, sodium nitrate, calcium nitrate, etc., from the group of nitrogen fertilizers; superphosphate, phosphorus flour, bone flour, Thomas phosphate, etc., from among the phosphorus fertilizers; and sylvinite, potassium salt, potassium sulfate, etc., from among the potassium fertilizers.

Approximate rates of application of mineral fertilizers to the soil are given in Table 41.

Mineral fertilizers must be stored in separate warehouse premises, protected from precipitation and from being wetted from the bottom. The warehouse should have bins with floors for storing wach kind of fertilizer. In dry weather the premises should be periodically ventilated. Even under these conditions the mineral fertilizers settle when stored for a long time, for which reason they should be dried and pulverized before application.

Mineral fertilizers may be supplied in the granular (grain) form. This fertilizer does not stick, it spreads well by sowing machines, and 1-2 days before its application to the soil a fertilizer mixture is made out of it, consisting of 2-3 components.

The fertilizers are spread by the TUR-7 general purpose conveyer

TABLE 41

Почва 1	Минеральные удобрения питательного (действующего) вещества 2		
	азотные 3	фосфорные 4	калийные 5
	Нормы внесения удобрений, кг/га 6		
7 Содержащие до 2% гумуса (улучшенные, как правило, органическими добавками — торфом, илом и т. д.)	60	90–120	90–120
Содержащие более 2% гумуса: 8			
Подзолистая супесчаная и легкосуглинистая 9	30–40	60–90	90–120
Подзолистая суглинистая и глинистая 10	30–50	90–120	40–60
Серый лесной суглинистый и выщелоченный чернозем 11	30–50	60–90	60–90
Суглинистая 12	20–30	60–90	30–60
Мощный чернозем 13	—	30–40	—
Каштановая 14	30–40	60	—

1) Soil; 2) mineral nutrients (active); 3) nitrogen; 4) phosphorus; 5) potassium; 6) rate of application of fertilizers, kg/hectare; 7) containing up to 2% humus (improved, as a rule, by organic additives, i. e., peat, silt, etc.,); 8) containing more than 2% of humus:; 9) podsolic sand loam and light argillaceous; 10) podsolic argillaceous and clay; 11) gray forest argillaceous leached black soil; 12) argillaceous; 13) deep black soil; 14) chestnut.

TABLE 42

Водородный показатель pH a	Степень насыщенности основаниями, % b	c Ориентировочные нормы извести, т/га		
		на песчаных и супесчаных почвах d	на суглинистых почвах e	на глинистых почвах f
4,5	50	3–4	5–6	7–8
4,5	50–70	1,5–2,0	2,5–3,0	3,5–4,0
4,5	70	—	—	1,5–2,0
4,5–5,5	50	1–2	3–4	5–6
4,5–5,5	50–70	0,5–1,0	1,5–2,0	2,5–3,0
4,5–5,5	70	—	—	0,5–1

Notes: 1) The rates given are for ground limestone, travertine or chalk; rates of marl are used with a correction coefficient of 1.5 for marl, 0.7 for roasted slaked lime and 0.5 for nonslaked lime.

2. Lime fertilizers are applied as early before the sowing as feasible. All fertilizers are used on the sod, with the exception of slaked and unslaked lime, which are applied only in the fall.

a) pH indicator; b) degree of base saturation, %; c) approximate lime application rates, tons/hectare; d) on sand sandy loam soil; e) on argillaceous soil; f) on clay soil.

spreader and spreader-type fertilizer spreading machines.

Mineral fertilizers are inserted into the soil by tooth harrows, cultivators or fisk harrows.

Readily soluble forms of fertilizers (nitrogen, potassium, etc.) are inserted to a depth of up to 2-3 cm by toothed harrows, or are not inserted at all, and not readily soluble fertilizers (phosphorus flour, bone flour, etc.) are inserted to a depth of from 10 to 20 cm by cultivators or disk harrows.

It is very important to apply the fertilizers at the proper time. Thus, it is desirable to apply the readily soluble fertilizers immediately before sowing or in two applications - before sowing and before germination. Not readily soluble fertilizers are applied in early spring or in the fall.

Lime should be applied to soil, as a rule, in the fall simultaneously with the basic cultivation of the soil, but not later than a week before the grass is sowed.

In order to ensure uniformity of application, the lime fertilizers are applied to the soil by special spreaders. Ordinary fertilizer spreaders may also be used. Approximate rates of application of lime materials are given in Table 42.

The lime fertizers are inserted by blade-type implements to the total depth of the layer being cultivated with subsequent disking.

80. SOWING THE FLYING FIELD

Flying fields are sowed by a mixture of perennial grass; the sowing operation is repeated over a number of years. Airport grass mixtures are usually compounded from 3-6 kinds of grass. In choosing the grass mixture it is important to know the characteristics of the grass, their relation to the soil, climate and operational conditions. Creeping stem and rhizomic grass are most extensively used as sod producers.

Creeping stem grass (fescue, wheat grass, timothy, couch grass, etc.,) upon developing form a highly branched and thick network of fibrous roots. Their tillering [sic] nodules are situated below the soil surface, due to which they stay alive in the case that the herbage is damaged by aircraft wheels or by temperature effects of a jet engine and retain their capacity for producing new shoots.

Rgizomic grass (Kentucky blue grass, brome grass, quack grass, etc.), also have tillering nodules. These grasses form a quite thick and extensive root system.

Normal development of rhizomic grass requires loose soil, with good air penetration. Creeping stem grass can develop normally also in more dense soil, which is the reason why they are most extensively used.

The kinds of seeds and the seeding rates are given in the landscaping operations plan. Before the flying field is sowed checks must be made of the quality of available seeds, the design sowing norms must be corrected in accordance with the seed quality and the grass mixture should be made up.

<u>Storage of Seeds and Checking Their Quality</u>

Only certified seed (not lower than the III class) may be used for producing a sod cover for flying fields. The sowing qualities of basic seeds of grass herbage are given in Table 43.

Warehouse premises must be prepared in time for storing seeds supplied to the airport. The warehouses should be dry and clean, without cracks in the walls or roof. To protect the seeds from moisture and from rodents the warehouse floor is raised by 0.5-1.0 meters from the ground surface. The warehouse premises should be provided with closable holes (air holes, air vents, etc.).

The seeds may be stored in the warehouse in the packing or they

The seeds may be stored in the war-house in the packing or they may be kept in the loose state in bins. The moisture content of sack stored dry grass seeds may not exceed 15% and for leguminous plants it may not exceed 13%. Sacks with seeds of each kind of grass and of each shipment are placed in separate piles up to 2 m high. When storing the seeds in the loose state they may be filled into the bins is layers not exceeding 1.25 m, with the permissible moisture content not exceeding 15%. If the moisture content is higher the layer height must not exceed 0.2-0.5 meters. Not sufficiently dry seeds must be dried in the sun or in a well ventilated place before piling.

When accepting the seeds each batch must be weighed. In addition a thorough check must be made to determine whether the batch contains spoiled seeds, which is determined by the smell of rotting and staleness. Systematic care must be organized of the seeds stored in the warehouse, which consists in ventilating the premises, shoveling of seeds in the bins and, if necessary, in additional drying.

It must be kept in mind that the quality of seeds changes on prolongued storage and their germinating capacity may drop. For this reason it is not permitted to issue from the warehouse seeds for sowing without checking them for their germinating power and purity. The quality of the seeds is checked not earlier than a month before sowing. It should be performed by analysis in the seed control laboratory of local agricultural organizations, or in the construction organization laboratory in accordance with generally accepted methods.

An average sample of seeds, taken from each uniform batch of these seeds is sent to the laboratory for analysis. Norm data, used in agriculture are utilized for determining the agricultural suitability of seeds.

Correcting the Sowing Rates of Seeds and Composing the Grass Mixture

In calculating theoretical sowing norms use is made of hundred percent or average agricultural suitability, which usually differs from the actual suitability of seeds available at the construction site. For this reason the composing of grass mixtures should be preceded by correcting the design sowing rates using as a basis the actual agricultural suitability of the component seeds.

If the design sowing rate was calculated using hundred percent agricultural suitability of seeds as a basis, then the actual seed rate can be determined by the formula

$$N_1 = \frac{100N}{C_\phi},$$

where N_1 is the actual (sowing) rate of seeds, kg/hectare; C_f is the actual agricultural suitability of seeds, % and N is the design rate of seeds, kg/hectare.

In calculating the design sowing rate for the average (class III) agricultural suitability, the actual seeding rate is determined by the formula

$$\bar{N}_1 = \frac{NC_{cp}}{C_\phi},$$

where C_{sr} is the average agricultural suitability of seeds, %.

The seeds are usually acquired by a planned order, for which reason the quantity of seeds brought to the construction site should exceed that calculated in the plan by 15-20%.

If seeds remain, they are used for subsequent supplementary sowing.

It is advantageous to tabulate the calculated data in tables which give the percentage composition of the grass mixture, the required quantity of seeds for operational sections and for the entire flying field.

TABLE 43

Название трав 1	Основные показатели качества семян, % 2			
	класс 3	количество семян основной культуры 4 (чистота)	всхожесть, не менее 5	хозяйственная годность семян II класса (средняя) 6
7 Верховой характер роста				
Ежа сборная 8	I II III	95 90 90	90 80 70	72,0
Житняк 9	I II III	95 90 80	90 80 65	72,0
Костер безостый 10	I II III	95 90 80	90 80 65	72,0
Лисохвост 11	I II	90 80	85 75	60,0
Овсяница луговая 12	I II III	97 92 85	90 85 75	78,2
Пырей ползучий 13	II III	85 75	80 50	68,0
Райграс высокий 14	I II III	95 85 80	90 80 70	82,45
Тимофеевка 15	I II III	97 95 90	90 85 75	80,75
16 Низовой характер роста				
Мятлик 17	I II III	95 85 75	75 65 60	55,25
Овсяница красная 18	I II III	95 90 80	85 80 60	72,0
Полевица белая 19	I II III	95 85 75	85 75 65	63,75
Полевица обыкновенная 20	II III	85 75	80 60	68,0
Райграс пастбищный 21	I II III	97 92 86	90 85 75	78,2

1) Grass designations; 2) basic seed quality indicators, %; 3) class; 4) number of seeds of the basic culture (purity); 5) germination, not less than; 6) agricultural suitability of II class seeds (average); 7) high-standing; 8) mixed orchard grass; 9) wheat grass; 10) brome grass; 11) foxtail; 12) meadow fescue grass; 13) creeping quack grass; 14) high-standing rye grass; 15) timothy; 16) low-standing; 17) meadow grass; 18) red fescue grass; 19) white bent grass; 20) ordinary bent grass; 21) grazing rye grass.

A grass mixture calculated per 1 hectare is prepared not earlier than 1-2 days before sowing in a quantity necessary for sowing the

given section. The seeds are sowed not all together, but by groups. The first group consists of large seeds: brome grass, meadow fescue grass, wheat grass, noncreeping quack grass, etc. The second group consists of fine seeds: timothy, meadow grass, white bent grass, clover, alfalfa, etc.

If the grass mixture consists of seeds of the first and second groups, then two separate mixtures are prepared. The seeds are weighed in calculated quantities, spilled onto a pile and thoroughly mixed. The grass mixture is prepared on a level area, covered by tarpaulins or on a floor.

To improve the sowing quality, ballast material, such as for example, dry peat crumbs, dry sawdust or millet shells, should be added to a grass mixture in which nonfree flowing seeds (high rye grass, foxtail, brome grass) predominate. Ballast is also added in those cases when the amount of seeds by weight is so insignificant that they cannot be uniformly sown by sowing machines. The rate at which the ballast is added is established depending on the type of seeds, the sowing machine type and the sowing rate. A ballast addition norm, once used, should not be used without changes during the entire sowing of the given grass mixture.

In order to ensure uniform mixing, the seeds should be mixed with the ballast in small batches, weighing approximately 20-30 kg. The proportioning is by weight.

Before being introduced into the mixture, the ballast material is thoroughly dried and presifted through a sieve with 5-6 mm holes. The correctness of the grass mixture thus composed should be checked by workers in the laboratory for each batch. For this purpose a weighing sample weighing 5-10 grams is picked from an average sample, spilled on a sheet of clean paper and thoroughly sorted by kinds. Then the

seeds of each kind thus picked are weighed separately on the same scales. The percentage content by weight of individual seed kinds in the mixture is determined by the formula

$$a = \frac{P}{\Sigma P} 100,$$

where a is the percentage content of seeds of the kind making up the mixture; P is the weight of seeds of the kind making up the mixture, grams; and $\Sigma P = P_1 + P_2 + \ldots + P_n$ is the sum of weights of seeds of individual kinds making up the mixture.

The deviations from the necessary specified weight may not exceed 5%.

Sowing the Seeds

The main tasks of the sowing operation is uniform spreading of seeds over the area of the flying field and inserting them to the necessary depth, which creates the most favorable conditions for swelling and sprouting of seeds and for their subsequent development.

The following agricultural requirements must be satisfied during sowing:

timeliness of sowing;

uniform sowing of seeds over the flying field area in conformance with the established rate;

uniform and complete insertion of seeds into the moist soil layer to the specified depth;

absence of flows and excessive sowing;

the sowed flying field should have a level surface.

The seeds are sowed in cultivated soil after the necessary fertilizers have been placed on it.

The seeds are sowed immediately after cultivation of the soil, but not later than the following day.

The best time for spring grass sowing is the period of sowing spring crops in the given region. The fall sowing coincides with the sowing of winter grains. But good results can be also obtained when sowing at different times, provided that the geographical conditions of the construction region are taken into account. Within the limits of the best times enumerated above, the sowing of grass mixtures should be performed close to the rainy period. The fall sowing may give good results, if enough time is left for sprouting of seeds and development of shots before the frosts start. When sowing immediately before the winter, the grass seeds should remain in the soil throughout the winter without germinating. For this reason the pre-winter sowing of grass is permitted only in regions where stable frost conditions ensure immediately.

The following are the most favorable times for grass sowing:

Kola peninsula, Karel'skaya ASSR, northern part of Arkhangel'skaya oblast	Spring
Belorussian, Lithuanian, Latvian, Estonian SSR and the right bank region of the Ukrainian SSR, the Leningrad, southern part of the Arkhangel'sk and other oblasts of the European part of the USSR to the boundaries of the Kurskaya and Voronezhskaya oblasts and the Mordvinian and Tatar ASSR	Early spring, fall (not later than the time for sowing of winter crops) and the summer in the rainy period
Southearn and south-eastern oblasts of the European part of the USSR, to the east of the Dneper	Fall (not later than the time for sowing of winter grains), early spring (first 4-5 days after sowing of early spring crops
North-eastern oblasts of the European part of the USSR with a more severe climate (Sverdlovskaya, Kirovskaya oblasts)	Late spring and beginning of summer (up to 15 June)
Western Siberia	Early spring, summer (July) and early fall (15 days before sowing winter grains)
Eastern Siberia	Early spring, summer (from the

	middle of July to middle of August)
Far East	Early spring, summer (August)
Asia Minor	Early spring and the fall-winter period.

Seeds of leguminous grass are characterized by comparatively frail shoots, for which reason it is recommended that they be sowed in all the zones, as a rule, only in early spring.

The seeds are sowed by the throw method, which gives continuous, uniform grass shoots. When sowing by the row method, the space between rows remains unseeded and serves as a source of dust and dirt during the airport operations. For this reason the row sowing method can be used, as an exception, only at safety strips.

The CZT-47 grain and grass sowing machines are used for sowing by the throw method. The TK-7 manure spreaders and the SD-24 row disk sowing machines can also be used.

When sowing grass by the throw method using the row sowing machines, the colters are removed and a spreading board is mounted instead directly beneath the seed distributing apparatus.

The flying field is sowed by rectangular strips, whose dimensions are calculated so that all the sowing operations can be completed in a single day.

To ensure rectilinear motion of the sowing unit, use should be made of markers. The right front wheel of the tractor is directed along the line of the markers, and when working with a crawler tractor, the external or internal edge of the right crawler is aligned with the line. Before the work starts the adjustment of the sowing machine to the specified sowing rate must be checked. Checking is performed by filling the seed box with a control quantity of seeds by weight, calculated for

sowing they are in a single loop.

The necessary control quantity of seeds is calculated by the formula

$$K=\frac{2BlH}{10000},$$

where K is the control quantity of seeds, kg; B is the width of the sowing machine coverage, meters; l is the strip length, meters and H is the sowing rate, kg/hectare.

If the seed being sowed do not conform to the calculated norms, then the position of the sowing regulater should be changed accordingly and the check should be repeated. To ensure uniform sowing by the sowing machine, it should be refilled not when entirely empty, but when the box is still filled to not less than 15-20% of its capacity.

The sowing rate provided for in the plan is sowed in 2 passes of the sowing machine, along and across the section.

Large seeds are sowed first, and then the fine seeds are spread.

If the sizes of the seeds making up the grass mixture are the same, then the sowing machines should be adjusted to sow half of the established norm in one pass.

The depth to which the seeds should be inserted is established depending on their size, the soil type and the climatic conditions of the construction region. The depth to which the seeds should be inserted into the soil is given in Table 44.

Large seeds are inserted into the soil by tooth harrows and light seeds are inserted by burshwood rakes. After inserting the seeds the flying field is rolled by light wooden rollers in 1 trace.

Care should be taken that a continuous crust does not form on the soil surface after sowing the grass. A crust that does form must be immediately loosened by a light nail-toothed harrow or with a wooden roller into which headless nails are driven in.

TABLE 44

Почвы a)	Районы нормального и избыточного увлажнения b)		Засушливые районы c)	
	семена d)			
	крупные e)	мелкие f)	крупные	мелкие
	глубина заделки семян в почву g)			
Глинистые h)	0,5—1,0	0—0,5	1,0—2,0	0,5—1,0
Суглинистые i)	1,0—2,0	0,5—1,0	2,0—3,0	1,0—1,5
Супесчаные j)	2,0—3,0	1,0—2,0	3,0—4,0	1,5—2,0

a) Soils; b) regions with normal and excessive moisture; c) dry regions; d) seeds; e) large; f) fine; g) depth to which the seeds are inserted into the soil; h) clay; i) argillaceous; j) sand loam.

When using SZT-47 two-box grain and grass sowing machines it is possible to sow by the combined throw and row sowing method. For this purpose the large seeds are filled into the large box of the sowing machine, from which they are sowed through disk culters into rows and are filled with soil to the required depth. Fine seeds are placed in the small box from which they are sowed by the throw method through freely suspended seed conduits, and are filled with soil from ring loops fastened to the sowing machine.

A unit such as the AZU-2 (Fig. 127) can be used for a accelerated forming of a sod cover at the flying field. The unit includes the FB-1, 9 rotary tiller, a mineral fertilizers spreader, a large roller for compacting the soil after the rotary tiller pass, a grass sowing machine and a small roller for inserting the seeds. The unit is drawn by the S-80 tractor.

81. CREATING A SOD COVER UNDER SPECIAL CONDITIONS

Creating a sod cover on sandy, loess and salty soils is a more complex problem and requires performing additional measures.

On ordinary sowing in sandy soils the sod cover forms very slowly and becomes suitable for use not earlier than in 3-4 years.

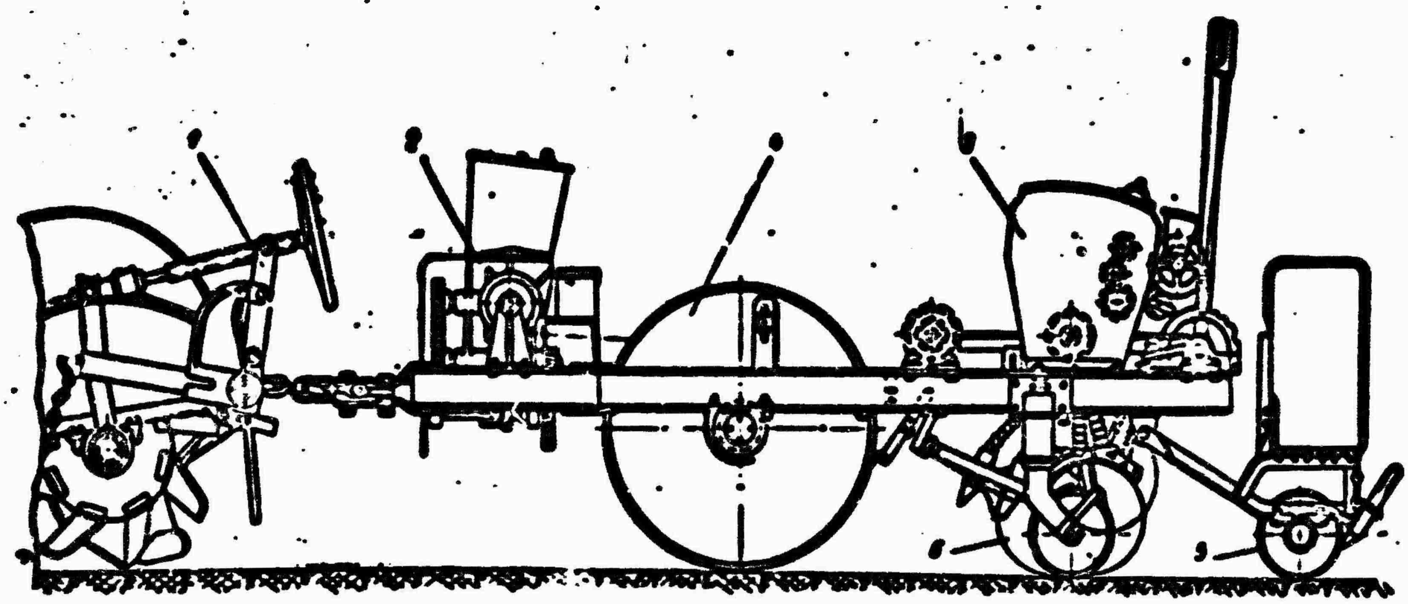

Fig. 127. The AZU-2 unit for accelerated formation of a sod cover. 1) FB-19 marsh rotary tiller; 2) fertilizer spreader; 3) grain and grass sowing machine; 4) large water filling roller; 5) small water filling roller; 6) disk colters.

For this reason the sowing should be preceded by increasing the soil's cohesion by introducing into it local binding materials, i.e., peat, peat compost or lake silt; the rate at which these are introduced is from 4 to 14% of the soil layer subjected to improvement. Lake silt is usually used in the form of a silt suspension.

The grass mixture composition should contain at least 50% of creeping stem grasses.

To accelerate the creation of sod covered flying strips on sandy soils, the sod cover is sometimes produced by replanting of sod prepared outside the airport limits. Before the sod layers are placed the subsoil should be loosened and fertilized.

Strips of this kind of sod are placed in rows tightly one against the other and the joints are filled with topsoil. It is expedient to replant the sod in the moist summer period.

When the natural texture of virgin loess soil is bared, it becomes

unstable and settle excessively. Here the settling can be observed not only under loads, but even when the surface is wetted by water. For this reason these soils must be thoroughly loosened before sowing to the maximally possible depth (not less than 25 cm). In addition, the soil is reinforced by binding materials. They are introduced into the soil and intermixed by using secondary loosening. The loosened soil must be abundantly wetted and rolled. To rapidly strengthen the soil surface the grass mixture should include rapidly developing grass, and the rate of sowing of perennial grass should be increased by at least a factor of two as compared to the standard rate.

Physiologically acid and neutral mineral fertilizers are used (ammonium sulfate, ammonium chloride, superphosphat, etc.).

In dry regions it is expedient to sprinkle the surface in the first 1-2 years.

When creating a sod cover on salty soil, its properties must be improved. The main measures in creating a sod cover on salty soil are partial or total removal of salt, selection of salt-resistant grass and the use of organic and mineral fertilizers.

The soil is desalinated by gypsum applications. The rates of gypsum application, depending on the extent of soil salt content, is taken within the limits from 3 to 10 tons/hectare. Deep plowing and loosening of soil is performed for the gypsum application. The grass mixture should contain the following salt-resistant grasses: creeping quack grass, sedge quack grass, wheat grass, alfalfa, etc.

It is recommended that 80-100 tons/hectare of peat and 20-40 tons/hectare of manure be used as the organic fertilizers. The mineral fertilizers used include nitrogen, phosphor and potassium at full strength. An important measure is also organizing the draining of the salt water from the flying field.

82. CONTROLLING THE QUALITY AND ACCEPTING THE AGRICULTURAL OPERATIONS

The following must be systematically controlled in performing agricultural operations for producing a sod cover at the flying field:

strict conformance to the established schedule for performing the various kinds of operations;

conformance to the proper processes for cultivating the soil, applying the fertilizers and sowing the seeds;

the quality of seeds and fertilizers supplied to the construction site and organizing their storage;

proper use of the kinds of norms of the grass [seeds] and fertilizers being spread.

After the soil cultivation is completed, the fertilizers are applied and the seeds sowed, the agricultural operations are surrended in a preliminary manner and acts for filled over operations are drawn up.

Final surrender of agricultural operations includes establishing the quality of the sod cover at location. The quality of the sod cover is estimated by the amount of shoots per unit area in 400 cm^2 (Table 45).

TABLE 45

Оценка качества дернового покрова 1	Количество побегов растений на площади 400 $см^2$ с преобладанием трав 2	
	3 низовых	4 верховых
Отличное . . 5 . . .	6 Более 300	6 Более 200
Хорошее . . . 7 . .	300—200	200—100
Удовлетворительное . 8	200—100	100—50

1) Evaluating the quantity of sod cover; 2) number of vegetation shoots at an area of 400 cm^2 with domination of; 3) low-standing grass; 4) high-standing grass; 5) excellent; 6) more than; 7) good; 8) satisfactory.

The density of the herbage is determined by a square frame 20 × 20 cm in size, inside which the shoots are counted. Measurements should be

over the entire area of the flying field and not less frequently than once per hectare.

The sod herbage should be uniformly closed. If individual sections are bare without a sod cover of with a thinned out herbage with an area greater than 100 m^2, the sod cover is considered unsatisfactory and the defective sections must be corrected.

At the time of acceptance the sod cover should have a sufficiently developed root system, i.e., not less than 60% of the roots should be located at a depth of more than 15 cm.

Manu-script Page No.	[Footnote]
374	The purpose served by the sod cover is presented in detail in the book "Izyskaniye i proyektirovaniye aerodromov" [Airport Surveying and Design] under the general editorship of V.F. Babkov. Avtotransizdat, 1959.

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